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GLACIATION OF NORTHWESTERN HOLMES COUNTY, OHIO.*

GEORGE W. WHITE,
University of New Hampshire.

CONTENTS.

PAGE
INTRODUCTION AND ACKNOWLEDGMENTS 429
DRAINAGE 430
RELIEF AND ITS EFFECT ON GLACIATION 432
GLACIAL BOUNDARY 435
DEPOSITS 437
Unstratified Drift 438
Ground Moraine 438
Terminal Moraine 440
Stratified Deposits 444
Valley Trains 444
Kames and Kame Terraces 445
Lake Deposits 451
LAKE BASINS AND PRESENT LAKES 452

INTRODUCTION AND ACKNOWLEDGMENTS.

In a part of Ohio the Wisconsin ice sheet advanced into a region of considerable relief, up to and just over the main preglacial divide. The effects of glaciation on a region of deep valleys, the character of the glacial boundary, and the deposits—especially the kames and kame terraces in the valleys—will be described in detail. The geology—stratigraphic, economic, and glacial—of all of Holmes County has been studied, but this paper is concerned with the glaciation of the northwestern part, because the glacial phenomena of a hilly region are well developed here. Northwestern Holmes County is bounded on the north by Ashland and Wayne counties and on the west by Ashland County. This area lies in Washington, Ripley, and portions of Knox and Monroe townships, and is shown on the Loudonville quadrangle of the United States Geological Survey. The areal map accompanying is drawn on a portion of that sheet.

*Published with permission of the Director, Geological Survey of Ohio.

To Mr. Wilber Stout, Director of the Geological Survey of Ohio, I am deeply indebted for co-operation and helpfulness at all stages of the investigation of the geology of Holmes County, and I take this means of expressing my sincere thanks and appreciation. My wife has helped in the preparation of the manuscript for which I am grateful.

FIG. 1. Index Map.

DRAINAGE.

Except for a small southern portion of this area which is drained by small streams directly tributary to the Mohican River or tributary to Black Creek, several miles south of the glacial boundary, most of the area is drained by Lake Fork of the Mohican River and its tributaries. Lake Fork, formed by the junction of Jerome Fork and Muddy Fork in Mohican Township, Ashland County, flows in a general southerly

direction through Lake Township, Ashland County and Washington Township, Holmes County and joins the Mohican River in the south part of the area near the Washington-Knox township line. The stream's present course is post-glacial. The preglacial drainage was by a large stream flowing east in a wide valley which has been traced from Wooster to Shreve, thence across northern Washington Township, Holmes County, to Loudonville, and on to the northwest.* This abandoned valley is spoken of by Leverett† as the "old Mohican" and will be referred to as the *preglacial Mohican* in the present report.

The valley of the present Lake Fork is made up of two parts. The first is that of a preglacial stream which rose in Mohican Township, Ashland County, and joined the valley of the preglacial Mohican at the Ashland-Holmes county line.‡ The other, and lower portion of the present valley was formerly occupied by a small stream flowing north from the southwestern part of Washington Township, Holmes County, to the valley of the preglacial Mohican in Section 33 of the same township. It is possible that this preglacial stream swung to the northeast in central Section 4 and entered the large valley in Section 34. A wide depression, partially drift filled is present here. This depression was the course of escape of considerable melt water from the ice.

With the coming of the glacier, the preglacial Mohican was dammed, the waters extended up the tributary valleys to the south, and escaped over low places in the divides, thus forming the present Lake Fork and Black Fork. It is possible that this diversion of the drainage took place in pre-Wisconsin time. Because of the narrowness of the valleys, it is thought that the formation of the present Black Fork and Lake Fork of the Mohican River did not take place earlier than Illinoian time.§ Other and smaller streams were also deranged by glaciation. Sigafoos Run, which formerly flowed north from northern Knox Township and entered Lake Fork (reversed) in Section 4 of Washington Township, was a larger stream than preglacial Lake Fork south of the preglacial Mohican. Sigafoos Run, where it leaves its old valley, flows directly west across a low place in the hills and enters the Mohican River just below the mouth of Lake Fork. This postglacial portion, about a mile in length, is a deep narrow gorge just at the glacial boundary.

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*Todd, J. H., Preglacial Drainage of Wayne and Adjacent Counties: Ohio Academy of Science, Special Papers, No. 3, pp. 46–67, 1900.

Ver Steeg, Karl, Drainage Changes in the Vicinity of Wooster, Ohio: Ohio Jour. of Science, Vol. 30, pp. 309–314, 1930.

†Leverett, Frank, Glacial Formations and Drainage Features of the Erie and Ohio Basins: Mon. 41, U. S. Geol. Survey, p. 164, 1902.

‡Hubbard, G. D., Stream Diversion near Lakeville, Ohio: Ohio Naturalist, Vol. 7, pp. 349–355, 1908.

§Killbuck Creek, which flows south through a wide valley in the central part of Holmes County, is believed to have been forced into its present course by some ice sheet earlier than Illinoian. The features of this valley will be discussed elsewhere.

RELIEF AND ITS EFFECT ON GLACIATION.

The main reason for the difference between the deposits in this portion of Ohio and those in other parts of the state is the relief of the region into which the ice sheet advanced. The country immediately to the north of the glacial boundary could not have been markedly different from that to the south.

The region in general is a plateau in early maturity. Flat areas, remnants of the Harrisburg peneplain,* remained on the divides at an elevation of approximately 1,220–1,240 feet. In northeastern Knox, southwestern Ripley, and northwestern Monroe townships the ridges, along the main preglacial divide mentioned by Coffey,† are about 100 feet higher, with monadnocks above the general level reaching to almost 1,400 feet. The elevation of the rock floor of the preglacial Mohican varies from 835 feet at Loudonville to 801 feet at Lakeville.‡ The present altitude of the abandoned valley, now partially filled with drift, is from 920 to 1,000 feet.

Glacial features dependent on the ice advance into such a terrain have been studied in Holmes County, and the area described shows these at their best development. They have been seen by the writer in Knox, Ashland, Wayne, and Richland counties, and probably are to be found to some extent in the other hilly portions of Ohio into which the ice advanced. It is hoped that further detailed work in the hilly regions east and west of Holmes County will extend our knowledge of this type of deposit.

Because of the relief of the region, several factors affected the work of the last ice-sheet near the glacial boundary:

1. Difficulty of ice advance.
2. Reversal of streams in valleys already formed, but no (or little) cutting of new valleys, except across divides to enter another valley.
3. Preservation of the major features of the preglacial topography.
4. Uneven melting and retreat of the ice front, with little forward motion during retreat and with many blocks and masses of ice left behind.

1. Obviously, if the glacier had to advance over an uneven and rugged surface, the rate of advance would be less than if it had a fairly level surface over which to move. Probably this accounts for the fact that none of the continental glaciers advanced as far in eastern Ohio as they did in the central and western part of the state.

2. If the glacier advanced over a reasonably level surface, the major valleys would probably be filled with drift, and upon melting of the ice, the streams would be forced to make new valleys and channels for themselves, which would seldom coincide with previous stream courses. On the other hand, if the glacier advanced over a region of

*Stout, Wilbur, and Lamborn, R. E., Columbiana County: Geol. Survey of Ohio, Bull. 28, p. 38, 1924.

†Coffey, G. N., Preglacial, Interglacial and Postglacial Changes of Drainage in Northeastern Ohio with Special Reference to the Upper Muskingum Drainage Basin: Ohio Jour. Science, Vol. 30, map p. 375, and p. 377, 1930.

‡Todd, J. H., Preglacial Drainage of Wayne and Adjacent Counties: Ohio Acad. Sci., Special Papers, No. 3, pp. 46–67, 1900.

marked relief, such as the one under discussion, and did not fill the valleys with drift, the streams on their reappearance after (and during) the melting of the ice, would find it easier to flow in valleys already present. The direction might be reversed and cols from one drainage system to another might be cut through low divides, but in large part the valleys would be preglacial.

3. The preservation of the major features of the preglacial topography in northwestern Holmes County and in other hilly portions of Ohio near the glacial boundary is due not only to the relief of the land over which the glacier advanced, but also to the fact that the advancing glacier was nearing its farthest extent and was hence undoubtedly thinner and much more sluggish than in its advance over the territory to the north. Although the territory to the north may have had less relief originally, the glacier being more active there was able to subdue the topography to a far greater degree than it was that farther to the south.

As detailed descriptions, which will be given later, show, the lowland is more or less covered with thick drift deposits. The high land, on the other hand, is in most places covered with a sheet of till, which is described as gound moraine. As a general rule, the higher the ridge the thinner the till. On some of the hilltops the till is thin or absent and the bedrock is exposed. The small amount of glacial erosion or deposition on the uplands is shown by the fact that the Harrisburg peneplain remnants are concordant on both sides of the glacial boundary. The gross form of the hills is preglacial.

The preglacial valleys are a dominant factor of the present topography. Some now carry streams; some do not. Not only are the major valleys of preglacial times still evident, but many of the smaller valleys seem to be of preglacial origin.

4. The glacial deposits in the valleys are the most noteworthy features in this area. These valley deposits are not of the usual valley train type which have been dissected by later stream erosion. They are deposits laid down by melt water around, between, and over blocks and masses of ice left behind in the valleys after the main ice front had melted back to the north. In some cases the stratified deposits were laid down in temporary lakes, but in most they seem to have been deposited by running water. Stagnation of the ice sheet, as postulated by Flint* in Connecticut, is not thought to have occurred in a very large part of Ohio. Near the glacial boundary, however, and in fact in this whole area, once the ice had advanced to its farthest extent, very little forward motion as the ice melted away, was present. The glacier near the ice front melted away in a ragged fashion leaving behind blocks and masses of ice where it had originally been thicker, namely, in the valleys. When the ice had advanced to its farthest extent, the ice front and that part of the ice directly back of the ice front, must have been thin on top of the ridges, as shown by the little erosion and small

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*Flint, R. F., The Stagnation and Dissipation of the Last Ice Sheet: Geogr. Rev., Vol. 19, pp. 265–289, 1929.

Flint, R. F., Glacial Geology of Conn: Conn. State Geol. and Nat. Hist. Survey, Bull. 47, 1930.

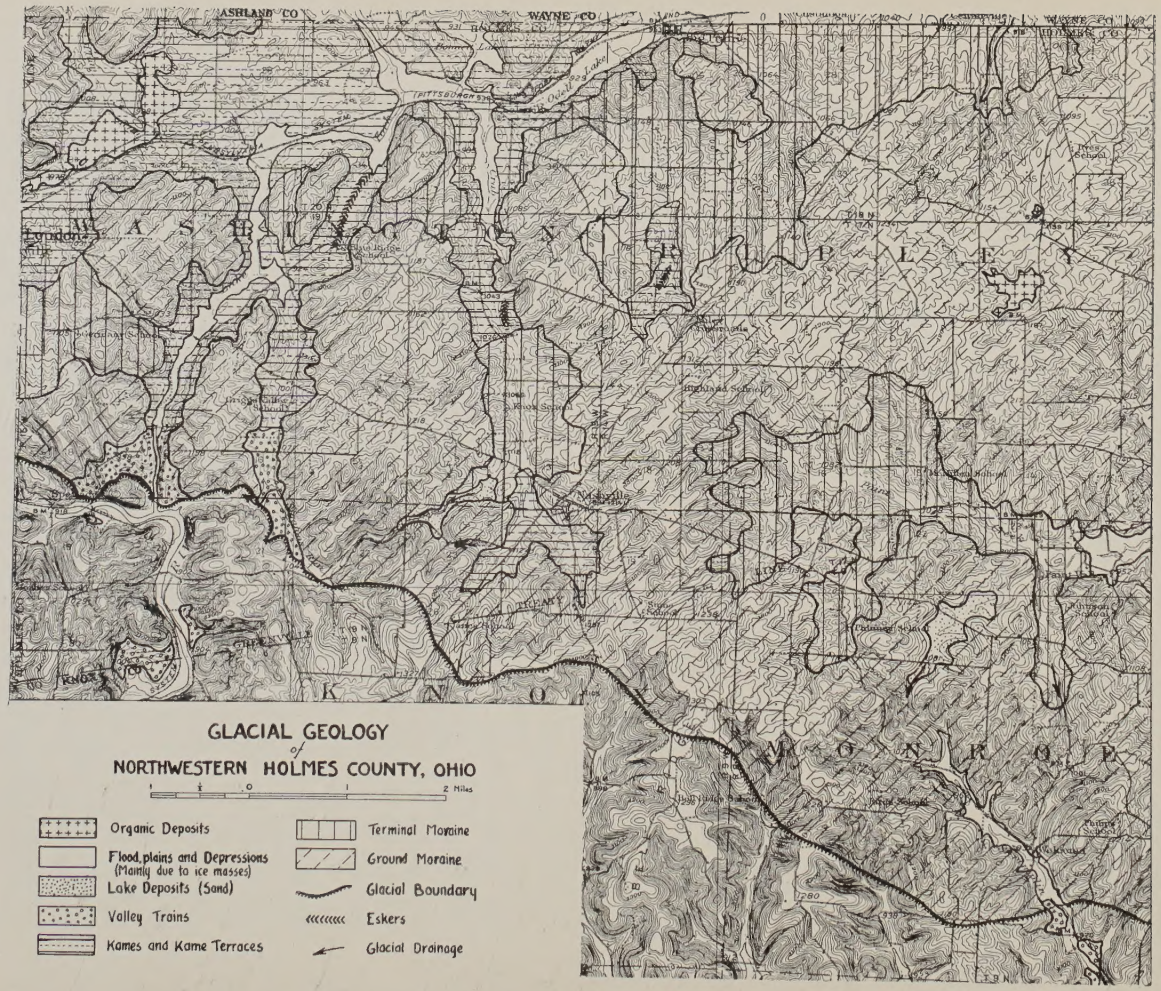

FIG. 2. Map of Northwestern Holmes County, showing Glacial Deposits.

amount of deposition there. The present valleys are from 200–300 feet deep, and if the thickness of the valley filling is added, they were from 100–200 feet deeper when the ice advanced into the area. Therefore, it is believed that when the ice melted away, it melted from the hilltops first, exposing the hills and ridges while ice still remained in the valleys, and that across this area there was no definite ice front at any time during the melting away of the glacier. The deposits in the valleys are such as would be deposited from and around these detached masses of ice remaining.

GLACIAL BOUNDARY.

The Wisconsin glacier advanced into Holmes County, reaching the top, and pushing slightly over the top of the main divide that runs in a general east-west direction across the county. This preglacial divide and the higher land near it was one of the factors which allowed the ice sheet to go no farther. From east to west the drift border runs one-half mile south of the village of Winesburg, southwest to just south of Berlin, crossing the valley of Doughty Creek at Wise School two miles south of Berlin, thence in a winding manner to Killbuck Creek at the junction of Sand Run with that stream one and one-half miles south of Millersburg. From Killbuck Creek the boundary is due west across western Hardy Township and eastern Monroe Township, crossing the valley of Shrimplin Creek three-fourths of a mile south of the hamlet of Welcome. One mile west of Shrimplin Creek it turns to the northwest across southwestern Monroe Township, crossing Bell Ridge three-fourths of a mile north of Bell Ridge School, passing just south of the top of the 1,400 foot knob two miles south of Nashville, and extending in an undulating fashion to Sigafoos Run in southwestern Section 22 in Knox Township. From here it follows Sigafoos Run to the junction of that stream with the Mohican River and thence in a westerly direction across the southern edge of Washington Township to the Holmes-Ashland county line. It passes about two miles south of Loudonville, just south of the Turkey Ridge School in Hanover Township, Ashland County.

Along the glacial boundary in Monroe, Knox, and Washington townships, topography and deposits, which are definitely of terminal morainic character, do not approach closer than two miles to the boundary except in the valleys, and at one place near Loudonville. The statement by Leverett* that "drift knolls with their fresh topography continue right up to the glacial boundary" and of Wright† that the boundary "line is very sharply defined", is true only in some of the valleys, especially those of Killbuck and Doughty creeks, in the central and western part of Holmes County.

Thick drift deposits are not found on the hilltops and ridges within a half mile, and in some cases a mile, of the boundary. Approaching

*Leverett, Frank, Glacial Formations and Drainage Features of the Erie and Ohio Basins: Mon. 41, U. S. Geol. Survey, p. 390, 1902.

†Wright, G. F., The Glacial Boundary in Western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois: Bull. 58, U. S. Geol. Survey, p. 60, 1890.

the boundary from the north in marking it out on the map, one passes from thick drift to thin drift, thence to discontinuous drift on this preglacial divide, and then into a region where the bedrock is at the surface and one finds only a few scattered foreign boulders. The farthest southerly extent of these scattered boulders has been taken as the limit of the Wisconsin ice advance. The deposits within a mile or more of the glacial boundary cannot be spoken of as a terminal moraine. Furthermore, those so called terminal morainic deposits closest to the glacial boundary are, as will be explained later, associated with low places in the surface and are not due to their proximity to the limit of glaciation. Valley deposits, such as the one in Lake Fork valley, are not morainic, although they have a knob and kettle topography, but are kame-like deposits. South and southeast of Loudonville along the Ashland-Holmes county line, morainic topography and deposits are found on the upland, the only place in the area where such is the case. Even here a belt almost a mile wide, in which the drift is thin and not morainic in expression, is found between the definite moraine and the glacial boundary.

The character of the marginal deposits is well shown along Bell Ridge which runs north and south in eastern Knox Township a little less than a mile west of Monroe Township. At Stones School, one and one-half miles south of Nashville, the drift is thick and bedrock is not visible. As one goes south from Stones School the drift continues thick for about a half mile. From this point onward the drift becomes notably thinner until about a mile south of Stones School it seems to end. However, as one progresses along the road and through the fields an occasional igneous boulder from one to two feet in diameter may be seen for about three-eighths mile to the south. The thickness of the drift south of Stones School is well shown where the Middle Kittanning coal is being stripped from the top of the ridge on the Wallace Bell farm. The overburden taken out by the steam shovel shows the material to be residual and not glacial soil. The boulders, never very abundant, become fewer and fewer until, a little more than a mile south of Stones School, no more boulders were observed beyond a line three-fourths of a mile north of Bell Ridge School. The glacial boundary was mapped at these last foreign boulders which were seen along the ridge top.

The same situation is found along the north-south ridge in western Monroe Township about a mile east of the Knox Township line.

One of the points of easiest accessibility, where the transition may be seen of the thick drift to the thin drift, of the thin drift to the discontinuous phase, and hence to the scattered boulder phase at the glacial boundary, is along the gravel road running south from Loudonville toward Spellacy, in Section 12 and Section 13 of Hanover Township, Ashland County. As one climbs onto the upland south of the Loudonville corporation limit, one crosses a morainic area which will be described later. The drift here is quite thick. At the line between Section 12 and Section 13 of Hanover Township the morainic area gives way on the south to a ground moraine area which is much flatter and less hummocky than the morainic area to the north. A quarter of a mile

south of this section line the drift is thin. The bedrock can be seen in the road ditch overlain by from two to four feet of till. One-half mile south of the section line the drift is so thin that the bedrock appears at the surface and no more till is seen. For about three-eighths of a mile, however, along the ridge traversed by this road, an occasional foreign boulder is present. Where the road crosses the county line the last foreign boulders were observed.

Two factors may be responsible for the thin edge of the drift deposit in this area. *First*, the ice front as it advanced up to and just over this main divide was undoubtedly quite thin and was not capable of carrying very much material. Apparently at its farthest extent the ice edge did not remain stationary for any length of time; rather it seemed to advance to the point of farthest extent and immediately draw back. Under such circumstances it is quite likely that little in the way of deposit could be made. On the northerly slopes of this main east-west divide the ice edge remained for a longer time and consequently the drift is thicker.

Second, this main divide of which these north-south ridges are spurs, is dissected deeply by southward flowing streams. In the valleys of these southward flowing streams little or no drift can be seen. The southerly slope of this divide may have been cut into by post-glacial erosion of the southward flowing streams working back to the north by headward erosion. In such a case any deposits would be removed from the valleys and the only remnants would be on the divide and ridges. Where the ridges are not very flat-topped, the material might creep and slide into the valleys and be removed by erosion. This factor is not thought to have been nearly so important as the first mentioned.

It might be noted in this connection, that the valleys of southward flowing streams in western Monroe and Knox townships, which head at the glacial boundary or beyond, (Shrimplin Creek excepted) contain little or no outwash material. Extended search of these valleys was made, and beyond an occasional granite pebble, no material, which could be identified as glacial outwash, was found. Probably these valleys originally had very little outwash material and postglacial erosion has removed that little.

It may be noted in this place that the Illinoian glacial boundary, which is supposed to extend south from a point one and one-half miles south of Nashville to the Walhonding River,* was not found. Indeed, in western Knox and Richland townships of Holmes County, supposed to have been covered by the Illinoian ice, no indication of glacial deposit of any age was seen. Neither was such indication seen in northeastern Jefferson Township, Knox County, nor in southeastern Hanover Township, Ashland County.

DEPOSITS.

The deposits left by the ice may be divided into two groups: till, or unstratified drift, and stratified drift. Till was deposited directly

*Leverett, Frank, Mon. 41, U. S. Geol. Survey, p. 225, 1902.

by the ice as it advanced over the region, or was dropped when the ice retreated. The stratified deposits were laid down by water flowing from the melting ice, depositing material in glacial streams or lakes.

Unstratified Drift.

The unstratified or till deposits are of two kinds: ground moraine and terminal moraine. The distinction is based on surface expression. The ground moraine is only slightly undulating, and is said to have a "weak" expression, whereas the terminal moraine has a "stronger" surface expression.

The Ground Moraine.

The upland surfaces and higher hill slopes are covered with boulder clay or till which is called the ground moraine. The average thickness of the till in this area is hard to arrive at because on some of the hilltops, especially near the glacial boundary, the till is absent and in other places, several miles to the north of the glacial boundary, especially over most of Ripley Township, the till may be 50 feet or more in thickness. The average thickness of the till in Wayne County to the north and northeast is 20 feet.*

The material making up the till was carried by the glacier from the north and deposited, both as the glacier advanced, when the material was sloughed off the heavily loaded lower part of the ice, and when the ice melted away. It was deposited with little or no sorting by running water from the melting ice. The ground moraine is divisible at some outcrops into two parts: a lower, more clay-like, compacted part; and an upper, more gravelly, loose part. These were called long ago by Upham† the "lower till" and the "upper till." The lower till, which is the thicker, is believed to have been deposited as the ice advanced and hence was packed down by the weight of the ice over it. The upper till was thought to have been deposited as the ice melted back and some water sorting is evident at places. This division of the ground moraine into an upper till and a lower till is better shown in the glaciated parts of central and eastern Holmes County and will be described more fully elsewhere.

The till is a sandy or silty clay, with many fragments of rock which are subangular and sometimes rounded. The size of these fragments varies from silt and sand grains to pebbles and boulders which may be 4 feet or more in diameter. The material of the till is largely of local derivation. It was derived mainly from shaly Waverly (Mississippian) sandstone which is the bedrock of most of the region‡ and of that to the north over which the glacier advanced to reach this position. Mixed in with the silt and Waverly sandstone fragments are pebbles, cobbles, and boulders of igneous and metamorphic rocks which were carried

*Conrey, G. W., Wayne County: Geol. Survey of Ohio, Bull. 24, p. 32, 1921.

†Upham, Warren, Chapter in Hitchcock, C. H., Geology of New Hampshire: Vol. 3, pp. 285–287, 1878.

‡Some lower Pennsylvanian layers are found on the higher hilltops. These are mainly sandstone. Near Nashville the rocks are as young as Allegheny.

down from the north of Lake Erie. These foreign boulders and cobbles do not make up nearly so large a proportion of the whole as they appear to do when an outcrop is first seen. When any given till bank is examined closely the percentage of foreign material is seen to be small. Most of this till, therefore, was carried but a short distance—but a few miles—and most of it is believed to have been carried less than 25 miles.

Near the top the till is buff or yellow in color. Where fresh exposures are seen, the lower part is usually bluish-gray. This is due to the unoxidized character of that more deeply buried. Both the yellow and the blue till are believed to have the same origin, the yellow having been oxidized, the blue not as yet oxidized. The depth of oxidation is variable, depending on permeability of the till, and slope of the land. Clear exposures, where slumping has not yet had a chance to occur, are rare and a definite average for the depth of oxidation of the till is not attempted.

The till is believed to cover the entire surface, but in the valleys it is concealed by later stratified deposits. The thickness of the ground moraine in the valleys is not known. How much of the valley filling is made up of gravel deposits, and how much is underlying till, is undetermined. Well records are not kept in sufficient detail so that the filling can be differentiated into gravel and till.

The topography of the ground moraine is somewhat variable. In general, the deposits were plastered on ridge tops or ridge sides. In many places the surface is smooth (not necessarily level) and does not undulate, so that very little suspicion of glaciation would be created in anyone's mind examining this area of weak expression for the first time. At other places, the ground moraine is somewhat billowy and grades with some intermediate stages into a hummocky topography, having a stronger expression, which is mapped as being topography of terminal morainic type. This will be treated under a separate heading below.

In northwestern Monroe Township the topography of the ground moraine is only slightly undulating, the undulating character increasing to the north in the valleys. In the valley of Paint Creek hillocks of drift cause a morainic topography.

In southern Ripley Township north of Paint Valley, in the region of Hopewell Church, the uplands are very heavily drift covered. Practically no bedrock is visible in this township. The till is quite thick; 25 feet or more may be seen in many places. The uplands here are gently undulating, but only a slight suspicion of sag and swell topography is present. Here the till is sandy in the upper part with the lower part more clay-like. The drift is only moderately stony with few stones over 6 inches in diameter. An occasional boulder up to 3 or 4 feet may be seen in the fields. This is the territory in which some of the finest farming land of Holmes County is found. This character of the drift is more or less continuous from Hopewell Church west as far as Miley Crossroads in central western Ripley Township. Here, however, the surface of the drift is more undulating and the boundary is hard to draw between the undulating ground moraine and the hummocky,

definitely terminal morainic area associated with the lowlands of the preglacial Mohican valley.

In eastern Washington Township in sections 1 and 36 the drift covering the hilltop is slightly undulating, but is known to be not very thick because bedrock shows in a few places. The uplands between Griggs Valley and the valley of Crab Run in sections 10, 11, 14, and 15 of Washington Township are quite thickly covered with till. Very few exposures of the bedrock are to be seen. The till veneer conforms to the surface of the preglacial hills. On the more or less flat upland a little undulation is present and the surface is slightly billowy on either side of the state road in sections 14 and 15. The ridge between the valley of Lake Fork and Griggs Valley in sections 16, 17, and 9 in the southern part of Washington Township is thickly covered with till on the northern end, but on the southern end, which is bounded by postglacial Sigafoos Run, the till is very thin and discontinuous. The character of the ground moraine south of the area of terminal moraine near the county line north of Spellacy has been described in connection with the glacial boundary.

The high hills in the northwestern corner of Washington Township and across the county line in Green and Lake townships of Ashland County are covered with till which seems to conform with the shape of the preglacial hillsides. The thickness and surface expression of the till in the parts of Green and Lake townships, Ashland County, which border on Holmes County, are of the same character as in Washington Township, Holmes County.

Except for the northeastern corner, Knox Township was invaded to only a small extent by the glacier. The drift covering is of the glacial boundary type rather than that of the hills farther to the north which were more heavily overridden by the ice. In the area north of Stones School in the northeastern corner of Knox Township, the drift is quite thick, obscuring the bedrock, and the topography is somewhat suggestive of a sag and swell type. South of the gravel area just south of Nashville, south of Stones School, and south of that portion of Sigafoos Run to the north of the glacial boundary, the till is quite thin and the bedrock is often visible. This region lies on top and to the south of the top of the main divide running across the area. Apparently the ice was just barely able to overtop this ridge. While the till is very thin here, the number of large igneous boulders, many of them 3 to 5 feet in diameter, lying on the surface, is greater than is usual any place else in the region.

The Terminal Moraine.

Areas having a "terminal morainic" topography are shown on the map. These areas do not seem to mark any definite ice edge where the ice front halted, making a thicker drift deposit, but rather they seem to be connected with low places of the region, and are mapped to show a definite type of surface. These discontinuous areas of terminal moraine could be connected from valley to valley, and a very respectable

series of loops produced. Conrey* found comparable conditions in southern Wayne County to the north:

> ". . . . drift accumulations of a morainic character extend across the southern townships in a discontinuous belt, being well developed in the valleys and of minor importance on the uplands. . . . . If these areas are connected across the intervening uplands they will correspond to the middle and inner or northern belts described by Leverett. The distribution of morainic accumulations in this region near the glacial border apparently has been determined to no small extent by the large preglacial valleys which are at places filled with drift knolls and ridges, while the uplands nearby show comparatively few morainic features. Especially is this true of the east-west valleys, that is, in those at right angles to the direction of the movement of the ice."

The material of the terminal morainic areas is much like that of the ground moraine, the major difference is in the "stronger" surface expression and not in the character of the material. As described under the ground moraine this till is composed of pebbles contained in a silty, clay-like matrix. Occasional areas of gravel deposits are found, but they are usually small and at the upper surface of the till.

Areas such as this, with a knob and kettle topography made up of hap-hazardly placed drift knolls, with depressions between, are usually interpreted as having been caused by the standing or the oscillation of the ice front over a narrow belt at the line of farthest ice advance, or later at some stage of the glacial retreat. The area south of Loudonville may have been formed in this way. The other areas, however, are definitely related to valleys rather than to any standing of the ice edge. The following explanation is offered for the deposition of these masses of unevenly surfaced till. The glacier advanced over the region, but it is supposed that the ice was not very thick, especially at the edge. The thickness of the ice over, and in the valleys would naturally be greater than that on the hilltops. As the ice advanced, considerably more material would be sloughed and scraped off the bottom of the ice in the valleys than on the hilltops. In fact, on the hilltops erosion rather than deposition by the advancing ice may have been the major feature. In the valleys more opportunity for ice blocks to accumulate in the drift would also be afforded. After the glacier had reached its line of greatest advance, it would melt away and down on the hilltops as well as back, so that the hilltops appeared above the surface of the glacier while the valleys were still filled with ice. The drift was already thicker in the valleys, for as the ice was thin on the hilltops, there could be less material contained in the ice here than in that in the valleys. Ice remaining in the valleys would take much longer to melt, would melt unevenly, and this uneven melting would contribute to uneven deposition of drift. Blocks and masses of ice would be carried in the drift slumping down from the sides of the parts of the glacier remaining and these would partially contribute to the formation of depressions

*Conrey, G. W., Wayne County, p. 26, and map in pocket.

in the present topography. By the time these ice masses in the valleys had melted pretty well down, the melt water would be concentrated between the ice and the valley walls, particularly if the ice were in a valley which had an open drainage way to the south. Under such circumstances the material deposited after an open drainage way was established would be more or less assorted and stratified. Such stratified deposits, deposited between masses of ice and the valley walls, are very abundant in the larger open valleys in the form of kames and kame terraces.

These morainic deposits are located in the upper part of the valley of Paint Creek in southern Ripley and northern Monroe townships; in parts of the valley of Crab Run, not taken up with kame deposits; in the large preglacial Mohican valley south and west of Shreve and along the south side of the valley between Big Prairie and Loudonville; and to the southeast of Loudonville in southern sections 6 and 7, and western Section 8, in the western part of Washington Township. This last mentioned area of terminal moraine is the only one which is on the upland. Even here this upland is not as high as the main divide. The deposits in the preglacial valley between Big Prairie and Loudonville may be in part morainic but if so are masked by stratified material.

Deposits in the preglacial Mohican valley south and southwest of Shreve just south of the Wayne-Holmes county line and the extension to the southwest south of Big Prairie, in northwestern Ripley Township are a part of those mapped and described by Conrey farther to the north in Wayne County.* Leverett has also described this area of morainic topography.† The latter merely mentions the deposits, but Conrey gives a good description of them in Wayne County. Neither of these authors, however, distinguished between the morainic knolls between Big Prairie and Centerville which are made up chiefly of till, and the morainic-looking deposits nearer the center of the old valley which are made up mainly of stratified material. In the present paper the two types of deposits will be separated. Just south of the county line between Centerville and Big Prairie the topography is of a sag and swell character rather than of a knob and kettle type. It is not well marked off from the undulating upper slopes and hilltops to the south. The boundary between the ground moraine and the terminal moraine is therefore indefinite at this place and the boundary might be drawn somewhat higher or lower. In this region the terminal moraine exhibits very little in the way of undrained depressions of the real kettle hole type usually associated with a terminal moraine. The territory to the south mapped as ground moraine does not seem, however, to have quite so much of a sag and swell character. Near Centerville the moraine is weakly developed. A bit farther to the west nearer Big Prairie, in Section 28 and northeastern Section 29, the surface is more irregular and hummocky. This is especially evident near Big Prairie where the terminal moraine grades into deposits of kame-like character. A small extension of the moraine south of Odell Lake seems to be plastered

*Conrey, G. W., Wayne County: page 27 and map in pocket, 1921.

†Leverett, Frank, Mon. 41, p. 391.

against the hillside and up to the top of the ridge, but soon merges into ground moraine to the south.

In central Section 31 in northwestern Ripley Township the terminal moraine extends to an altitude of approximately 1,160 feet. All of Section 32 around Sprang School shows well developed knob and kettle topography. Some of these knobs are somewhat gravelly, but the material on the whole is mostly till. These knobs rise from 10 to 30 feet above the general level.

The upper or western portion of the valley of Paint Creek and its tributary valleys are partly filled with drift which is quite thick. The drift is known to be more than 130 feet thick in the valley bottom on the north side of Paint Creek in southeastern Section 15 in central southern Ripley Township, where a well on the farm of E. V. Gorrell is 130 feet deep and does not reach bedrock. The elevation of the well head is 1,020 feet. Mr. Gorrell states that a good flow of water was attained at this depth in a sand layer. Most of the drift here has an undulating surface and in places it approaches a knob and kettle topography. It is somewhat like the morainic surface in northwestern Ripley Township—not especially strongly developed. Prominent knolls of till are present in places, however. The streams tributary to Paint Creek seem to have established their courses from one depression to another. In the head waters the original topography is rather effectually masked. Probably preglacial Paint Creek occupied a good sized valley. Related to this morainic area small patches of gravel are present here and there, mostly near the streams and especially near Paint Creek. These are so small, however, that they were not mapped separately.

On the higher hills the drift is also fairly thick. Bedrock through here outcrops but rarely and not at all at the lower levels. The upland surfaces are flatter than those lower down, but are undulating in many places. The boundary between the ground and the terminal moraines is often not well marked. The ground moraine on the hilltops has a weaker expression than on the surfaces lower down. The boundary is therefore drawn where believed to best represent the change in surface character.

In the vicinity of Knox School in southeastern Washington Township in the valley of Crab Run, a small area has a terminal morainic expression. For about a half-mile on either side of the stream low drift knolls partly fill the valley and are plastered against its sides. The knolls in this area are feebly developed and the area as a whole can by no means be taken as typical of a terminal moraine. It is thought that the knolls are more definite than any undulations on the upland nearby and so the area is mapped as different from ground moraine.*

A small area of drift knolls is present in northern Washington Township between the lower part of Crab Run and Lake Fork. In this small area mainly in Section 35, till knolls are banked against the hillside, and across the low divide to the west. This area is somewhat

*Conrey, G. W., Wayne Co., pp. 34–36, and map, describes such areas in Wayne County as "minor morainic areas on the ground moraine."

related to areas of stratified drift nearby, but seems to be made up entirely of till.

One of the best developed areas of morainic topography is in sections 6 and 7, Washington Township and Section 12 of Hanover Township, Ashland County, just south of Loudonville. It is very close to the glacial boundary, in fact, it is the closest in the region. It differs from those previously described, being on the upland rather than in the valleys or along the valley sides. It attains an elevation of 1,160 feet in Section 12 of Hanover Township and 1,240 feet in northwestern Section 8, Washington Township. The maximum development, however, is not reached on this last higher hilltop. On the north, the area grades into a region of gravel kames and kettles, where the drift is thicker. The material is till, with only a small amount of gravel intermixed near the surface. At the county line and along the gravel road leading from Loudonville to Spellacy just west of the county line, the surface is very hummocky—real knob and kettle topography. Drift knolls 10 to 20 feet or more in height are scattered about and the depressions between are in many cases undrained kettle holes. Several of these kettle holes are partly filled with water, making small ponds and others show that small ponds existed in them until very recently. The largest of these is over 300 yards in diameter, and several have a diameter of more than 150 yards.

Stratified Deposits.

Stratified deposits of several types exist in the area. They are: valley trains, kames and kame terraces, eskers, and lake deposits. Valley trains will be mentioned briefly; eskers will be included in the treatment of kames and kame terraces, which will be treated in some detail because of their importance in this region; and the lake deposits will be located and described.

Valley Trains.

Valley trains, consisting of outwash deposited by melt water concentrated in streams flowing to the south, were deposited in the lower portion of the valley of Shrimplin Creek; in the lower part of Lake Fork valley; in the lower part of Griggs Valley; and in the valley of the Mohican River. This last extends far to the south and on down the Walhonding and Muskingum rivers. Along Shrimplin Creek and along the Mohican River these valley trains have been cut into by later stream erosion, and the outwash material remaining is in terrace remnants along the valley sides. The areas of valley train gravels in the region are shown on the map. The major one, that in the Mohican valley, of which that in the lower Lake Fork valley really is a part, extends far beyond Holmes County and is complicated by association with Illinoian glaciation in part of its course below Brinkhaven. A discussion of its features does not come within the scope of this paper. The one in the lower part of Shrimplin Creek valley more properly belongs with the deposits of Killbuck valley, which will be described elsewhere. That in the lower part of Griggs Valley will be taken up again in the description of the kames and kame terraces in that valley.

Kames and Kame Terraces.

Kames and kame terraces are the most unusual features connected with the glaciation of this region. Kame terraces have been described in the eastern United States,* but their only previous notice in Ohio, as far as the present writer is aware, is a brief mention of "esker terraces" by Wright,† located ". . . . in the River Styx in Medina County, between Seville and Wadsworth, and in the Mohecan River,‡ in Wayne County, in the vicinity of Wooster." As explained previously, it is believed that ice remained in the valleys after it disappeared from the hilltops. In a few cases, after the ice melted below the hilltops, temporary lakes were formed between the remaining ice mass and the hillside, and in these temporary lakes silt and gravel deposits were laid down. Some evidence of these ice-margin lakes is to be found, but apparently the ice-margined lake stage in any of the valleys was not very long lived. Flint§ has described ice-margin lake deposits of Connecticut in great detail. Most of the deposits in the valleys of this area, while bearing some similarity to Flint's ice-margin lake deposits, are not thought to have been deposited so much in lakes as in temporary channels between the ice remaining in the valley and the valley sides. Spillways⊙ such as are associated with the Connecticut ice-margin lake deposits, are not present in this area. The water was flowing to the south throughout the period of deposition of most of this material.

After the ice in the valley melted completely out, a hummocky terrace-like structure was left along one or both of the valley walls, with a depression—really an elongate kettle or series of kettles—in the central portion of the valley through which the present stream flows. The sides of these kame terraces show ice-contact slopes, where the gravel, formerly in contact with the ice mass, had slumped down upon melting of the ice. (See Fig. 3). These slopes have previously been regarded as stream cut, but while some stream cutting has taken place, most of the slopes are regarded by the writer as original ice-contact slopes. A method of testing the ice-contact character of the slopes bordering the streams is to compare them with those bordering the kettle hole lake basins, especially of Odell and Long (Bonnett) lakes. The slopes bordering the lakes must of necessity be original—no stream cutting can have occurred. By comparison therefore it is found that the two

*Salisbury, R. D., Surface Geology—Report of progress, N. J. Geol. Survey, Ann. Rept., 1892, 93, p. 156, 1893.

Alden, W. C., The Physical Features of Central Massachusetts: Bull. 760, pp. 47–49, 1924.

Goldthwait, J. W., Geology of New Hampshire: Handbook No. 1, N. H. Acad. Science, pp. 35–36, 1925.

†Wright, G. F., Postglacial Erosion and Oxidation: Bull. Geol. Soc. America, Vol. 23, p. 285, 1912.

‡Killbuck Creek is probably intended here.

§Flint, R. F., Glacial Geology of Conn.: Conn. State Geol. and Nat. Hist. Survey, Bull. 47, 1930.

⊙Flint, R. F., Glacial Geol. of Conn., p. 99.

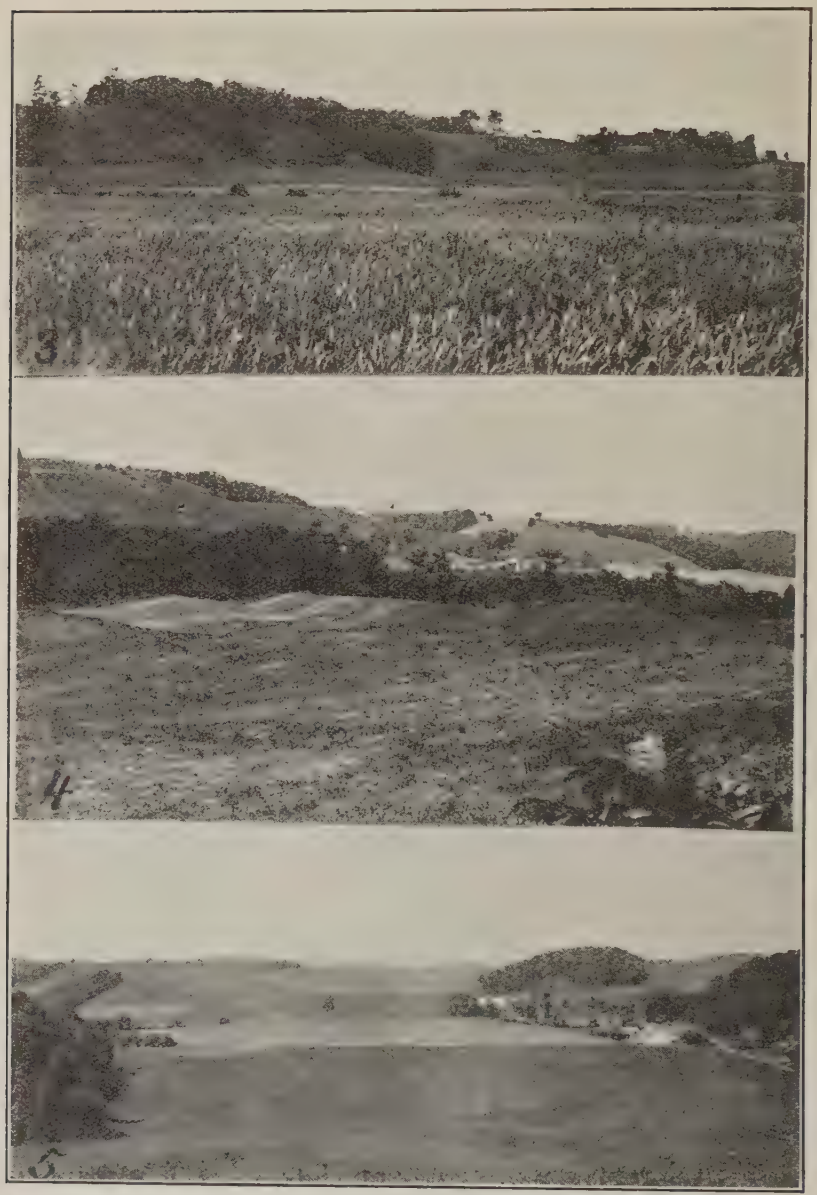

FIG. 3. Typical kame terrace showing ice-contact slopes. Stagnant ice rested in the foreground. West side of Killbuck valley, near Holmesville. (This is in Prairie Township, just east of the area under discussion.)

FIG. 4. Looking northwest across the valley of Lake Fork, southern Section 8, Washington Township. Kame deposits in foreground, till veneered rock-hills in background.

FIG. 5. Valley train in abandoned valley of Sigafoos Run (Griggs Valley). Looking north from glacial boundary, in Section 21, Knox Township. The till-covered hills on either side are remnants of the Harrisburg peneplain.

kinds of slopes are similar, and that the depressions through which the streams flow are merely drained elongate kettles.

Kames and kame terraces will be treated together. A kame in the present paper is a gravel knoll, deposited at or near an ice edge by running water. All gradations, from single isolated kames, to groups, and to terraces made by kames packed closely together, are found.

Valleys which carry these kame and kame terrace deposits are: the abandoned preglacial Mohican valley from Shreve to Loudonville; the valley of Lake Fork, both north and south of the great preglacial valley; the abandoned valley called Griggs Valley, which was formerly occupied by Sigafoos Run in preglacial times; the upper and especially the lower part of the valley of Crab Run; and a small valley northwest of Miley Crossroads in central western Ripley Township.

While these are the only kame and kame terrace deposits to be discussed in the present paper, it might be noted here that similar deposits are found in the deep valleys in the surrounding glaciated territory. Such deposits are particularly well developed in the valleys of Killbuck and Martins creeks in the central northern part of Holmes County.*

Lake Fork Valley—In the southern part of the valley of Lake Fork, that is, in section 8 and 17 of Washington Township, Leverett† observed:

> " . . . . in the midst of the valley, at considerably lower levels, there is a knob-and-basin topography. The basins cover several acres and the centers are depressed 10 to 15 feet or more below their rims. Their bottoms are peaty and marshy, and therefore presumably filled to some depth. They are surrounded by knolls of various sizes, form and trend, while near them at the border of the valley are level-topped gravel deposits standing 50 feet or more above the general level of the morainic tracts in the valley. Phenomena somewhat similar to these are displayed in several valleys in northwestern Pennsylvania just above the glacial boundary, and may be common in other parts of the glaciated district. Their cause is not well understood, but it is thought that they are probably due to the lingering of an ice mass in the central portion of the valley after a passage for the escape of water from beneath the ice had been opened along the borders of the valleys."

These knolls are regarded by the present writer as kames and not as morainic knolls. These kames fill the valley northward to about the place where the Loudonville-Millersburg road crosses the valley in northeastern Section 8. From the state road north to where Lake Fork leaves the preglacial Mohican valley, the kame-like knolls seem to be more confined to the valley sides and a more definite depression is present in the center of the valley through which Lake Fork flows. This depression is believed not to have been cut by the stream but to re-

*White, G. W., An Area of Glacier Stagnation in Ohio: Journal of Geology (in press), 1931.

†Leverett, Frank, Mon. 41 U. S. Geol. Survey, p. 391.

present the place where an ice block or blocks rested while deposits were being banked up between the remaining ice and the valley side. These deposits, while rudely terrace-like, do not have a flat top. (See Fig. 4.) The surface is very hummocky, being made up of kames and kettles. The inner borders of these terraces nearest the stream are ragged and represent ice-contact slopes against which the ice rested while the gravel was being deposited between the ice and the valley wall.

These gravel deposits in this part of Lake Fork valley seem to have been deposited by running water and not to have been deposited in lakes held in between the remaining ice and the valley wall. While these structures do not have flat tops such as would be deposited by a stream flowing south, it is believed that the absence of the flat top is because smaller ice blocks were numerous between the valley walls and the main mass of ice in the center of the valley. The gravel would be deposited between these masses of ice and perhaps entirely over them, so that originally this deposit may have had a flat top. When the many buried ice blocks melted, the surface became hummocky and kettled. If many blocks of ice of different sizes were buried in the terrace, it might show no traces of an original horizontal surface after the melting of all the buried blocks.

In northern Section 4 and southern Section 3 the deposit on the west side of the stream against the valley wall is gravel. Most of the deposit on the east side, however, is undulating till deposit which has been mapped as terminal moraine.

Griggs Valley—The abandoned valley of Sigafoos Run, which somewhat parallels the valley of Lake Fork before joining it in Section 4, Washington Township, is locally called "Griggs Valley." Gravelly kames, which are related to the kame gravels of the Lake Fork valley, are found from Griggs Valley School to the north end of the abandoned valley. Some of the gravel is quite coarse, containing cobbles up to one foot in diameter. In northeastern Section 9, in the north end of the valley, the material becomes more and more mixed with till. The deposit is quite terrace-like at the north end of the valley in central eastern and northeastern Section 9.

A considerable amount of melt water from the ice made its way to the south down this abandoned valley to Sigafoos Run which now flows out through the hills at the glacial boundary. A valley train, which is fairly level, heads at some kames about a quarter of a mile south of Griggs Valley School. (This is well illustrated in Figure 5.) It is made up of both sand and gravel, some of the latter being quite coarse. The elevation here is about 1,060 feet and decreases to 1,020 feet at the south end of the valley train. Some of the material of the southern part of this valley train may have been washed down from the vicinity of Nashville through the gorge-like valley of Sigafoos Run which carried melt water from an area to the west of Nashville. When the ice finally withdrew, the old outlet of Sigafoos Run to the north was choked. The new outlet through the hills to the west had carried sufficient melt water to cut the new channel so deep that it was retained.

Abandoned Valley, Sections 3 and 34, Washington Township—This abandoned valley, formerly tributary to the pre-glacial Mohican, is partly filled with kames, with an esker in the central part. The kames are 20 to 30 feet high and not packed tightly together. The evidence of many ice blocks and masses is quite clear in this short stretch. The fact, that ice in this valley was old and rotten and had no forward motion whatever, is shown by the presence in the center of this valley of the largest esker in Holmes County. This esker is a sharp ridge, 50 feet high in places and less than 20 in others, extending almost north and south for about a mile. The top is not level but quite ragged. The material is sand and fine gravel. The esker structure is probably much higher than it now appears because it is partially buried in later kame and wash deposits. Some drainage in addition to the subglacial drainage through the esker tube came down here beside the ice to join Lake Fork and then flow out to the south.

Crab Run Valley—The lower half and the headwaters of the valley of Crab Run have some gravel deposits separated by an area of weak terminal moraine already described. The deposits in the lower part of the valley will be taken up first.

To the south of the village of Lakeville are some of the best developed kame terraces of the whole area. A terrace made up of fine gravel is present for a little over a mile on either side of Crab Run south of Lakeville. The terraces are over a quarter of a mile wide and have a very hummocky surface with ice-contact slopes nearest the stream. Crab Run has done some lateral cutting but in the main the shallow inner valley is the low place or connected kettles left when the ice finally melted out of this valley. In places the terraces are 40 feet above the stream. Near Lakeville they have an elevation of about 980 feet. The tops of the terraces slope to the north, indicating that probably the drainage was north in the valley of Crab Run into Lake Fork and thence south, as is the present day drainage. The absence of gravel deposits in the southern part of the valley around Knox School precludes the possibility of any drainage to the south.

The terrace effect dies out and becomes rather an area of separate kames about a mile from Lakeville. Well developed kames continue from where the definite terrace seems to end up the valley into sections 11 and 12. The kames are higher and better developed near the valley wall, and are lower near the center of the valley. The material seems to be mainly fine sand and gravel. On the eastern side of the valley at the corners of sections 11, 12, 1, and 2 a north-south esker one-quarter mile long parallels the valley.

From the northern part of sections 11 and 12 south to the Loudonville-Nashville road is an area of low till knolls described previously. West and south of Nashville the head of the valley of Crab Run is partly filled by a few low gravelly kames which are also plastered against the hillsides. Above the area of gravelly kames the upper slopes are only slightly undulating and the deposit is till. One mile southwest of Nashville are low kame swells with some 20 to 40 foot kames to the west against the hillside. The material as seen in a small pit is mostly fine gravel. This area of kame and kettle topo-

graphy is quite subdued and not nearly as pronounced as that in the valleys here-to-fore described. These kame gravels could very well have been deposited off a retreating ice edge rather than around detached blocks, as was the case in many of the other valleys. The melt water from this area drained through a spillway to the southwest which connected the headwaters of Crab Run with the headwaters of Sigafoos Run. This took water from the vicinity of Nashville only and not from as far north as the kame deposits near Lakeville.

Central Western Ripley Township—A small area of gravel deposits is found in central western Ripley Township northwest of Miley Crossroads, practically confined to eastern Section 6. This is in the headwaters of a small stream flowing north to Odell Lake. The material is fine gravel and sand, mostly aggregated in kames and kame swells. The slopes of some of the kame swells are quite ragged, showing good ice-contact characteristics. A small esker 20 feet high and a quarter of a mile long, trending north-northeast is present in the center of the valley. The northern part of this small area of gravel deposits is surrounded by terminal moraine and on the south it is in contact with the upland and its ground moraine.

Preglacial Mohican Valley—The gravel deposits in the preglacial valley, where it crosses north and northwestern Washington Township, constitute the largest area and in some repects the most complex of any in the valleys of the region. Most of these deposits were laid down by running water, but some material was deposited in temporary lakes. Here also the largest continuous ice blocks were left as shown by present basins some of which now contain lakes.

This valley is filled to a considerable depth. At the south end of Odell Lake a well 200 feet deep did not penetrate to the bedrock. At Lovells Corners where the 3 C highway crosses from Holmes County into Ashland County, a well 110 feet deep was in gravel all the way. The valley filling is mainly aggregated in single and massed kames. The material is principally gravel, with some sand intermixed. A few of the knolls seem to contain some till and these may represent almost completely buried terminal morainic knobs. Level expanses are found here and there between some of the kames. This material, which was deposited in short-lived lakes, is more sandy and thinner bedded than that of the kames. In the northwestern corner of Washington Township in sections 29 and 30 is a well-marked flat area of sand and fine gravel, the elevation of which is approximately 1,000 feet. It is probably a wash plain deposited around ice blocks.

From Big Prairie to Lakeville the south side of the valley has gravel kames banked against the valley wall. The central part of the valley is occupied by the depression partially filled by Odell Lake. Just east of Big Prairie is a large elongate kame, trending east and west, made up of fairly coarse gravel. The gravel is 30 to 40 feet thick with apparently sand below. The gravel in the kames from Big Prairie to Lakeville, banked against the hillside, seems to be fine and sandy, with many sand layers. To the southeast the kame area grades into an undulating region of terminal moraine.

North of Lakeville, between that village and the county line, is a considerable area of kames and kettles. The surface is not as level as it appears from an examination of the topographic map. From Lake Fork west to Loudonville is an area of very well developed kames and kettles, some of the kettle holes containing tiny ponds. Other kettle holes, once containing ponds, as shown on the topographic map made in 1912, now are bogs. In general most of the smaller kettle holes are fairly well drained, because they are in gravel and the ground water soon percolates below the level of the bottom of the kettle holes. Most of these are from 10 to 30 feet deep. The larger basins in this region will be described under the heading of "lake basins."

In the vicinity of Loudonville and for a mile to the east, the valley is constricted and the area of kame deposits is narrower than that farther to the east. In northwestern Section 6, Washington Township, near Loudonville the gravel kames are especially well developed and many marked kettle holes, some of them over 100 yards across and 20 to 40 or more feet deep, are present between the kames. The gravel is medium to fine-grained. The bedding dips in different directions at various angles. The area just beyond the Loudonville city limits, crossed by the state road to Millersburg, is one of the most typical kame and kettle areas in the region under discussion.

Lake Deposits.

As the ice advanced into the region, the northward flowing valleys were the sites of temporary lakes, and drainage was established over the lowest divides to the south. It was in this way that the lower course of Lake Fork was established. The glacial outlets of all the other lakes were not cut down deeply enough to be permanent streams. As the ice retreated, the valleys, which slope to the north, again became the sites of lakes which emptied to the south through low places in the divides. These lakes were ephemeral, and surprisingly little evidence of their existence remains. The old beds of two of these lakes—flat areas of sand and silt—were observed. One, which covers an area about one mile long and one-half mile wide, is shown on the map in north central Monroe Township, a mile east of Phinney School. Lake deposits of this sort are also found at the low pass between the head waters of Crab Run and Sigafoos Run along the Knox-Washington township line one mile west of Nashville. Below the sandy surface, varved material probably exists, but no exposures are present.

Other lakes of an even more temporary character existed from place to place where water was trapped between the stagnant ice in the valleys and the valley walls. Such areas are not mapped separately because they are in intimate association with the kame gravels with which they are mapped.

Deposits of small temporary lakes are found around the bases of some of the kames in the preglacial Mohican valley. These show that the drainage from one low point to another was at places quite poor after the deposition of drift in this part of the region. On the north side of the 3 C highway in northern Section 32 of Washington

Township poorly exposed, undulating lacustrine layers were measured as follows:

	FT.	IN.
Gravel, very poorly sorted	4	0
Layers of sandy silt and darker silty clay, varying from 1/64 to 1/4 inch in thickness	5	6

A small deposit, the laminations of which may be seasonal, was observed along a lane in north central Section 6 of Washington Township, at an elevation of from 1,020 to 1,040 feet. This deposit is as high, or higher, than most of the kames to the west and north. The clay layers were from 1/8 to 3/4 of an inch thick and the sand layers from 1/64 to 1/4 of an inch thick. Each layer of clay had many thin sandy partings. This deposit is at the edge of an area of kame gravels where apparently a small lake was trapped between the stagnant ice to the north and the valley wall to the east. The material was measured here as:

	FT.	IN.
Gravel	8	0
Clay and sand, (varved?)	7	6

The peat and muck deposits, in some of the small kettle holes and in some of the larger ice block depressions such as those in the northwestern corner of Washington Township, are later than glacial times and do not come within the scope of the present paper. Some have already been described.*

LAKE BASINS AND PRESENT LAKES.

The lake basins in the region are all glacial in origin and are associated with stratified material in the preglacial Mohican valley. They are all kettle holes, some of great size. As the ice melted many large depressions were left in the stratified material in the valleys. The borders of these depressions show excellent ice-contact slopes where the gravel was built up against the ice blocks. Here there is no question about the slopes being trimmed by lateral planation of streams, because these depressions are occupied by lakes. By analogy, therefore, between the slopes of the lake basins and the slopes of the depressions now occupied by streams, the conclusion has been drawn as to the original ice-contact character of the slopes described previously. Those that were drained became part of a stream channel. Those which were not drained remained as lakes, some of which have been gradually filled, forming marshes.

The largest is Odell Lake, between Big Prairie and Loudonville. It is about one mile long and about one-quarter of a mile wide. It occupies a depression considerably longer but the same width as the lake. The lake is reported to be 15 feet or less in depth throughout. The Odell Lake depression was at one time occupied by a block of ice, which extended from Big Prairie almost to Lakeville.

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*Dachnowski, Alfred, Peat Deposits of Ohio: Geol. Survey of Ohio, Fourth Ser., Bull. 16, pp. 32–33, 77–78, 1912.

Long (Bonnett) Lake is in the northern part of Section 26, extending slightly over the county line into Ashland County. It is about three-eights of a mile long and a little less than a quarter of a mile wide. The basin which it occupies is about twice the length of the lake. This lake is considerably deeper than Odell Lake, having a uniform depth of 22 to 23 feet. The slopes of this basin show well developed ice-contact features.

Two large depressions and a smaller one, now connected by narrow channels and the whole drained by Plum Run, are found in the northwestern corner of Washington Township as shown on the map. The bottoms of these are at an elevation slightly deeper than 980 feet. The basins, partly filled with silt and organic material, have been artificially drained, and except for a few small patches lower than the usual level, are farmed. The compound basin of this old swamp is made up of smaller coalescing kettle holes rather than being one simple depression. The boundary slope is quite ragged, rising 20 to 30 feet above the former bog. An interesting feature is the presence, well out from the margins of the depression, of several small kames 20 to 30 feet high.

A LIST OF PARASITIC COPEPODS AND THEIR FISH HOSTS FROM LAKE ERIE.

WILBUR M. TIDD,
Ohio State University.

A collection was made of the parasitic copepods of Lake Erie and some of its tributary waters by the writer while assisting on the Cooperative Biological Survey of Lake Erie during the years of 1927, 1928, and 1929. The collecting has been continued throughout the present summer of 1931 at the Franz Theodore Stone Laboratory. In all, some fifteen hundred fish of thirty-eight species have been procured for examination and thirteen species of parasitic copepods found, eight of which are new to the waters of Lake Erie. The following list of thirteen species is a preliminary report on the above collection. The records are for Lake Erie proper unless otherwise noted.

Family ARGULIDÆ.

Argulus appendiculosus Wilson. Host—Found upon a bullhead (probably *Ameiurus nebulosus*). Specimen taken by Professor Stephen R. Williams. New to Lake Erie.

Argulus stizostethii Kellicott. Host—The six specimens captured were all taken while swimming in the plankton. This species was described by Kellicott from specimens on the blue pike "Stizosthethium salmoneum" (probably *Stizostedion glaucum* Hubbs) taken from the Niagara River at Buffalo, New York.

Family Ergasilidæ.

Ergasilus centrarchidarum Wright. Hosts—The rock bass (*Ambloplites rupestris*), and the large-mouth bass (*Aplites salmoides*). New to Lake Erie.

Ergasilus caeruleus Wilson. Hosts—The sauger or sand pike (*Stizostedion canadense canadense*), the blue pike (*Stizostedion glaucum*), the gray pike (*Stizostedion vitreum*), the yellow perch (*Perca flavescens*), the blue gill (*Helioperca incisor*), and the trout perch (*Percopsis omiscomaycus*). New to Lake Erie.

Ergasilus versicolor Wilson. Host—The channel catfish (*Ictalurus punctatus*). New to Lake Erie.

Ergasilus cotti Kellicott. Host—The rainbow darter (*Poecilichthys coeruleus*) from Lake Erie drainage. This is the first time *Ergasilus cotti* has been reported since it was described in 1892 by David S. Kellicott from specimens found on the sculpin, "Cottus ictalops" (*Cottus bairdii bairdii* Girard) captured near Westerville, Ohio.

Family Lernaeopodidæ.

Achtheres ambloplitis Kellicott. Host—The rock bass (*Ambloplites rupestris*).

Achtheres micropteri Wright. Host—The large-mouth bass (*Aplites salmoides*). New to Lake Erie.

Achtheres pimelodi Kröyer. Hosts –The channel catfish (*Ictalurus punctatus*), and the yellow bullhead (*Ameiurus natalis*) from Sandusky Bay.

Achtheres coregoni (S. I. Smith). Host—The whitefish (*Coregonus clupeaformis*).

Salmincola inermis (Wilson). Host—The lake herring or cisco (*Leucichthys artedi*). New to Lake Erie.

Family Lernaeidæ.

Lernaea cruciata (Le Sueur). Host—The rock bass (*Ambloplites rupestris*).

Lernaea tortua (Kellicott). Host—Straw-colored minnow (*Notropis deliciosus stramineus*). New to Lake Erie.

NEW AND INTERESTING PLANKTON ALGÆ FROM LAKE ERIE.

LEWIS H. TIFFANY,
Ohio State University,
AND
ELBERT H. AHLSTROM,
Northwestern University.

For the last five summers a rather intensive study has been made of the plankton algæ* of Lake Erie along the Ohio shore and in the region of Gilbraltar Island, upon which is located the Franz Theodore Stone Laboratory of Ohio State University. During the past summer particular emphasis has been given to the plankton algæ of Put-in-Bay Harbor of South Bass Island and of ponds on Middle Bass and North Bass Islands.

The three Bass Islands lie near the Ohio shore in Lake Erie, some few miles north of Catawba Peninsula. Gibraltar Island lies in Put-in-Bay Harbor off the north shore of South Bass Island, thus giving considerable protection to the harbor from wind and wave action. In the harbor are located three separate bays having "semi-pond" characteristics and known as Squaw Harbor, Terwilliger Pond, and Hatchery Bay.

Some of the following species and varieties collected in this region are apparently undescribed to date. Others because of their varied characteristics or rare occurrence in North America deserve special mention.

Chroococcus limneticus Lemmermann.

(Pl. I, Figs. 2–10.)

Bot. Centralb. 76: 153, 1898; Kryptogamenfl. d. Mark Brandenburg 3: 57, Fig. 8, 1907; G. M. Smith, Phytopl. In Lakes Wis. Pt. I: 29, Pl. 1, Fig. 4, 1920. *Chroococcus limneticus* Lemm. var. *distans* G. M. Smith, Bull. Torr. Bot. Cl. 43: 481, Pl. 26, Fig. 26, 1916; *Chr. limneticus* Lemm. var. *carneus* (Chod.) Lemm. Arkiv f. Bot. 2 (2): 101, 1904; Smith, Phyopl. In L. Wis. Pt. I: 30, Pl. 1, Fig. 6, 1920.

Chroococcus limneticus has been observed as a common plankton alga of Lake Erie for a number of years and was particularly abundant this past summer. It is quite variable

*A more comprehensive report of the plankton algae of the Put-in-Bay region of Lake Erie is in an advanced state of preparation.

in size, color, and arrangement of cells within the colony. The diameter of the cells varies from 3.5 to 26μ. The color may be light bluegreen, pale bluegreen, olive green, gray, grayish purple, or even brown. In some colonies the cells are very close together; in others cellular arrangement can be found that is typical of the various recognized varieties of the species. In fact, it is possible to find a complete intermediate series between the species proper and its so-called varieties. In spite of this marked intergrading, it seems desirable to recognize var. *purpureus* (Snow) nov. comb. and var. *subsalsus* Lemm. (see below). In the measurements of a great number of individuals of these algæ three definite means of sizes are noted, corresponding to the species itself and the two above-named varieties. The usual cell size of the species is 6.5 to 9μ.

Var. *distans* G. M. Smith and var. *carneus* (Chodat) Lemm. are merely growth variations of the species. In fact, every gradation in size, shape, color, and arrangement of cells was observed in the Lake Erie material between the species and these two varieties.

Var. **purpureus** (Snow) nov. comb.

(Pl. I, Figs. 11–15.)

Chroococcus purpureus Snow, Bull. U. S. Fish Comm. 22: 383, Pl. 4, Fig. 18, (1902) 1903; *Chr. limneticus* var. *elegans* G. M. Smith, Trans. Wis. Acad. Sci. Arts & Let. 19: 619, 1918; Phytopl. In. Lakes Wis. Pt. I: 30, Pl. 1, Fig. 8, 1920.

Colonies circular to semicircular in front view, somewhat flattened in side view, inclosed by a spherical or oval, hyaline, homogeneous envelop. Individual sheaths of cells may or may not be conspicuous. Cell contents homogeneous. Color blue-green to grayish-purple, or even brown—grayish purple being the usual color.

Diameter cells (without sheath) 13–26μ, usual diameter 16–19μ.

This large variety of *Chroococcus limneticus* is undoubtedly the form Snow described from the Lake Erie region under the name of *Chr. purpureus*. It is often grayish-purple in color, markedly more so than is usual for the species proper. The color is, however, variable. The specimens from East Harbor are predominantly grayish-purple, while those of the Put-in-Bay region are bluegreen or grayish-green. This variety is also identical with var. *elegans* G. M. Smith. Though the latter name is more appropriate, Snow's *purpureus* has priority. It differs from the species proper in its larger size. Due to marked changes in color at different seasons of the year in members of the Chroococcaceæ, names based on color characteristics are not particularly significant.

Var. **subsalsus** Lemmermann.

(Pl. I, Fig. 1.)

Forschungsbr. a. d. Biol. Stat. Zu Plon 8: 84, 1901; Arkiv f. Botanik 2 (2): 101, Pl. 1, Fig. 9, 1904; G. M. Smith, Phytopl. In. Lakes. Wis. Pt. 1: 29, Pl. 1, Fig. 5, 1920.

Diameter cells (without sheath) 3.5–4.5μ.

This variety establishes a range below the usual size of the species as does var. *purpureus* above the usual size.

Merismopedia convoluta Brebisson.

(Pl. II, Fig. 19.)

Kuetzing Spec. Algar. 472, 1849; Hansgirg, Prodromus der Algenfl. v. Bohmen, Pt. 3: 142, Fig. 52, 1893.

Diameter cells, 3.5μ; length of cells, 4.5μ.

The most common Merismopedia in the lake seems referable to this species. The colonies are usually large, seldom having less than 64 cells and frequently numbering thousands. The cells are definitely longer than wide. The colony is flat when the number of cells is small, but when composed of a large number of cells it has a tendency to roll under or overlap itself. The cell color is pale bluegreen, much lighter in the center than around the edges.

Var. **minor** (Wille) nov. comb.

(Pl. II, Fig. 20.)

Merismopedia convoluta Brèb. f. *minor* Wille *in* Geitler, Cyanophyceae *in* Pascher, Süsswasserflora, Deutsch. Öster. u. d. Schweiz 12: 106, 1925.

Diameter cells, 2.75μ; length, 3.5μ.

This variety is definitely smaller than the species proper. In addition the cells are more closely packed together. All colonies observed were large—several hundred to over a thousand cells. Its abundance and regular occurrence with the species seem to warrant varietal rank.

Gomphosphaeria lacustris Chodat.

(Pl. II, Fig. 22.)

Bull. Herb. Boiss 6: 180, Figs. 1A–1G, 1898; *Coelosphaerium roseum* Snow, Bull. U. S. Fish Comm. 22: 387, Pl. 55, Fig. 17, (1902) 1903; *Gomphosphaeria rosea* (Snow) Lemm. Kryptogamenfl. d. Mark Brandenburg 3: 80, 1907.

This alga is a very common, often abundant, form in the lake. The color, though usually pale bluegreen, may be rose

or brown. It is undoubtedly the alga that Snow described under the name of *Coelosphaerium roseum* and which later Lemmermann assigned to the genus Gomphosphaeria. Many specimens were found that suited the description as given by Snow in every detail. She realized the resemblance to *Gomphosphaeria lacustris*, but she placed too much emphasis upon the color of the alga under her observation.

Marssoniella elegans Lemmermann.

(Pl. II, Fig. 21.)

Ber. d. deutsch. bot. Ges. 1900: 275; Kryptog. d. Mark Brand. 3: 93, Fig. 9, 1910; Geitler, Cyanophyceae *in* Pascher, Süsswasserflora Deutsch., Öster u. d. Schweiz 12: 120, Fig. 155, 1925. ? *Coelosphaerium radiatum* G. M. Smith, Roosevelt Wild Life Bull. 2 (2): 136, Pl. 3, Figs. 9–10, 1924.

Diameter cells, (1–) 2–3μ; length cells, 5–6μ.

This alga appears rarely in the lake proper. It agrees with *Coelosphaerium radiatum* Smith, which Geitler refers to *Marssoniella elegans*, except in the absence of any observable sheath. The Lake Erie specimens usually have 32 to 64 cells in a colony (never less than 16) and have two to four axes of radiation.

The genus Marssoniella must be placed with the Chroococcaceae. There is no justification for its assignment to the Chamaesiphonaceæ by Lemmermann. The relationship to Coelosphaerium is evident, but it seems best to regard it as distinct.

Dictyosphaerium planctonicum nov. sp.

(Pl. II, Fig. 17.)

Colonies usually ovoid and relatively small, containing less than 40 cells. Cells bluntly rounded, ovoid, or markedly ellipsoid. Chloroplasts one or two, parietal, laminate, each with a single pyrenoid. Two (sometimes four) cells often contained in separate envelopes within the colony. Sheath of colony (?) absent.

Cells 8–9μ broad, 12–16μ long.

This species differs from *D. ehrenbergianum* Naegeli (Gatt. einz. Algen 73, Pl. II, Figs. Ea-E1, 1849) in the larger size, in the apparent absence of a sheath around the colony, and in the curious arrangement of cells in multiples of two, which often have a separate envelope surrounding them. Were it not that some colonies lack this latter feature, the assignment of this species to the genus Dictyosphaerium is open to question. Abundant in Put-in-Bay Harbor.

Oocystis eremosphaeria G. M. Smith.

(Pl. II, Fig. 18.)

Trans. Wis. Acad. Sci. Arts & Let. 19: 630, Pl. 14, Figs. 8–9, 1918.

Cells ovoid, up to twice as long as broad. Solitary or in families of two or four. Chloroplasts numerous (40–60), parietal, lenticular, each with a single pyrenoid. Cell wall thick, with a conspicuous polar nodule.

Cells 17–31μ broad, 21–45μ long.

This species is present in the plankton of Lake Erie, though apparently never very common. It is frequently smaller than the dimensions given by Smith, and the original description has been modified accordingly.

Treubaria varia nov. sp.

(Pl. II, Fig. 16.)

Treubaria triappendiculata G. M. Smith (non Bernard), Trans. Amer. Micros. Soc. 45 (3): 177, Pl. 9, Figs. 19–23, 1926.

Cells three- or more angled (up to eight-), usually four-, pyramidulate to quadrate in shape (usually pyramidulate), sides of cells concave or straight. Angles broadly rounded, each bearing a single hyaline spine that gradually tapers to near the end, where it terminates abruptly in a sharp point. Chloroplast massive, completely or nearly filling the cell, with one or four pyrenoids (usually four).

Diameter cells (with spines), 48–89μ, (without spines), 8–19μ; spines (20–) 25–38μ long, 3–6μ broad at base.

This species appears to be quite distinct from *T. triappendiculata* Bernard.* The latter according to Bernard's description has three spines usually 15–20μ long, seldom up to 30μ. The spines, moveover, are distinctly punctate. The chromatophore is supposedly flat with a single pyrenoid. *T. varia*, on the other hand, seldom has less than four spines. A few specimens with a single pyrenoid, which show them to be young plants, have spines only 20μ long. An interesting note here is that the spines during June-July averaged about 30μ long, while during August the average length was about 25μ, indicating a definite seasonal variation. The spines are somewhat variable in shape. The usual type seems intermediate between those of *T. triappendiculata* and *T. crassispina* Smith (*loc. cit.*, p. 178, Pl. 10, Figs. 2–5). A few taper to an acute point, while others have subparallel sides that taper abruptly to a sharp point.

*Dept. de l'Agr. Indes Neerland. 1908: 170, figs. 544–548.

The cell itself ranges in size from 8–19μ, the usual size being about 13μ. These dimensions are larger than those recorded by Smith and much larger than those of the original *T. triappendiculata*. Smith notes the absence of cavities between the base of the spines and the cell wall. The presence or absence of cavities is a variable feature, many cells having distinct cavities, while others lack them. The chromatophore in mature cells always has four pyrenoids, and not single, as Bernard noted for *T. triappendiculata*. It seems desirable, on the basis of the above data, to establish a new species for the American specimens as being distinct from the original *T. triappendiculata*.

This species is very close to *Borgea planctonica* G. M. Smith (Ark. f. Botanik 17: 2, 1922). It differs in having the cells pyramidulate to quadrate in shape, while the latter species has spherical cells. Perhaps the differences are too slight to warrant generic separation.

Micractinium pusillum Fresenius var. **longisetum** nov. var.

(Pl. III, Fig. 34.)

Colonies of four to eight cells. Cells spherical, with 5–8 delicately tapering very long setae on the faces not adjacent to other cells. Chloroplasts single, parietal, cup-shaped, with one pyrenoid.

Diameter cells (without setae), 6–8μ; setae up to 65μ long.

This variety with unusually long setæ was collected at the mouth of the Maumee River.

Micractinium eriense nov. sp.

(Pl. III, Figs. 32 and 33.)

Colonies of 2, 4, or 8 cells (usually 4 or 8, the latter more common). Cells spherical with 8–13 delicately tapering setae on the faces not adjacent to the other cells. Cells usually in a pyramidulate arrangement. Chloroplast single, parietal, cup-shaped, with a pyrenoid.

Diameter cells (without setae), 7–10μ; length of setae, 20–35μ.

This species differs from *M. pusillum* in its larger size and more numerous setæ. The usual number of setæ for each cell is 11 or 12, and the colonies do not contain more than 8 cells. Colonies of *M. pusillum* are normally larger than 8 cells, although colonies of var. *elegans* G. M. Smith (Trans. Wis. Acad. S. A. & L. 19:631, Pl. XII, Fig. 4, 1918) are quite similar to those of *M. eriense*. Collected from Wehrle Pond and

Haunck Pond on Middle Bass Island and from Smith Pond on North Bass during August.

Golenkinia radiata Chodat var. **brevispina** nov. var.

(Pl. III, Fig. 31.)

Cells spherical, solitary, containing numerous, delicate, short setae. Chloroplast single, cup-shaped, with a pyrenoid.

Diameter cells (without setae), 8–19μ; length setae, 8–15μ.

This variety differs from *G. radiata* Chodat (Jour. de Bot. 8:305, Pl. III, Figs. 1–24, 1894) in the much shorter setæ. It differs from *G. paucispina* W. & G. S. West (Trans. Roy. Acad. 32 (Sec. B):68, Pl. I, Fig. 18, 1902) into whose cell size range it runs, in the more numerous, light, and more delicate setæ, and in the cup-shaped chloroplast. Found in Haunck Pond on Middle Bass Island throughout the summer.

Golenkinia maxima nov. sp.

(Pl. III, Fig. 30.)

Cells spherical, solitary, with fairly long, delicately tapering setae, which are often bent after a short distance from the cell. Chloroplast single, apparently filling the cell, with a large pyrenoid.

Diameter cells (13–) 17–22μ; length setae, 35–45μ.

The setæ of this species are markedly heavier than those of *G. radiata*, and much darker, though comparable in length. The cell diameter is larger than that of *G. radiata*. *G. maxima* is near *G. paucispina* in size of cell, but differs in the much longer setæ. Found in Terwilliger Pond and Squaw Harbor throughout the summer.

Lagerheimia citriformis (Snow) Smith.

(Pl. III, Figs. 27 and 28.)

Phytopl. In. Lakes Wis. Pt. I: 130, Pl. 30, Figs. 1–2, 1920.

Diameter cells (without setae), 8–20μ; length cells, 13–26μ; length setae, 25–60μ.

More variable in Lake Erie than the original description would indicate. Although the chloroplast is usually single, individuals with two parietal chloroplasts are not uncommon. The length of the setæ varies greatly. Specimens from the mouth of the Maumee River have setæ up to 60μ long.

Lagerheimia citriformis var. **paucispina** nov. nom.

(Pl. III, Fig. 26.)

Chodatella subsala var. *citriformis* Woloszynska, Hedwigia 55: 201, Pl. 7, Figs. 15–19, 1914.

Cells ovoid to ellipsoid with a small obtuse projection at each pole. Poles with 2–3 (4) long, hyaline, delicately tapering setae at the base of the polar projections. Chloroplast single, parietal, with one pyrenoid.

Diameter cells, 8–9μ; length, 10–14μ.

Because of its very pronouncedly citriform shape, this alga should be regarded a variety of *L. citriformis* (Snow) Smith and not of *L. subsalsa* Lemm. (Forschungsbr. a. d. Biol. Stat. Plön 6: 193, Pl. 5, Figs. 2–6, 1898). It resembles the latter only in its small size, and differs from the former in its smaller dimensions and its fewer setæ.

Lagerheimia longiseta (Lemm.) Printz var. **major** G. M. Smith.

(Pl. III, Fig. 25.)

Phytopl. inland Lakes Wis. Pt. I: 130, Pl. 30, Figs. 10–12, 1920. *Chodatella longispina* Walton, Ohio Biol. Survey Bull. 24: 64, Fig. 37, (1930), 1931.

Diameter cells, 12–25μ; length, 15–37μ; length setae, 40–60μ.

This alga is quite common in the plankton of the lake region. Its size range is greater than that given by Smith. *Chodatella longispina* is apparently only a large form of this variety. It would appear from Walton's discussion of his species that he is not entirely familiar with the literature on this group of algæ, particularly the thorough American work of G. M. Smith.

Lagerheimia wratislawiensis Schröder.

(Pl. III, Fig. 29.)

Ber. d. bot. Ges. 15: 373, Pl. 17, Fig. 7, 1897; Smith, Trans. Amer. Micros. Soc. 45 (3): 180, Pl. 12, Figs. 10–14, 1926.

Diameter cells (without spines), 3–7μ; length cells (without spines), 10–14μ; length of spines, 14–26μ.

Collected from Haunck Pond, Middle Bass Island. Previously reported for this country only from Iowa.

Franceia tuberculata G. M. Smith.

(Pl. III, Fig. 37.)

Trans. Amer. Micros. Soc. 45 (3): 182, Pl. 12, Figs. 27–30, 1926.

Diameter cells (without setae), 5–12μ; length cells (without setae), 8.5–21μ; length of setae, 7–32μ.

This alga is quite common in the ponds of Bass Islands, though it is seldom found in the lake proper. Colonies consist of 2-4-6-8 (usually 4) closely appressed and parallel cells. No evidence of a gelatinous sheath. Tubercles always distinct, being at times raised as much as 3μ above the cells.

Franceia tuberculata var. **irregularis** nov. var.

(Pl. III, Figs. 35 and 36.)

Cells large, joined in colonies of 4 to 6 or 8 cells; half of the cells in the colony usually arranged at right angles to the other cells, though the arrangement may become somewhat irregular. Cells broadly ovoid with rounded poles; cells where not in contact with other cells clothed with rather long delicate, non-tapering setae with a distinct tubercle at the base of each.

Dimensions as in the species (above).

The variety is characterized by the irregular arrangement of the cells in the colony, instead of having the long axes of the cell always parallel.

Selenastrum bibraianum Reinsch var. **gracile** (Reinsch) nov. comb.

(Pl. II, Fig. 23.)

Selenastrum gracile Reinsch, D. Algenfl. d. Mitt. Th. v. Franken, 1867: 65, Pl. 4, Figs. 3 a–b, 1867.

This alga should not be given more than varietal rank, if it is to be recognized at all. It may be merely a growth form of *S. bibraianum* (Pl. 2, Fig. 24). The two algæ were always found growing together, and occasional colonies had cells typical of both. Autospores have frequently been observed in *S. bibraianum* but never in var. *gracile*. Young colonies of typical *S. bibraianum* are apparently identical with the variety.

Crucigenia apiculata (Lemmermann) Schmidle var. **eriensis** nov. var.

(Pl. III, Fig. 41.)

Coenobe four-celled with a relatively large open space in the center; coenobia frequently multiple. Cells quadrately arranged with base and median part of inner sides in mutual contact, but with the apices and outer faces free. Cells elongate, somewhat lunate, with free ends truncate, and provided on the inner apex with a short conical projection; usually a second projection at the side of the base away from the center of the coenobe. Cells with one to four parietal, disciform chloroplasts, with one pyrenoid.

Diameter cells, 3–5μ; length cells, 6–10μ.

The free apices of this variety have a superficial resemblance to *Crucigenia truncata* G. M. Smith (Phytopl. In. Lakes Wis.

Pt. I: 146, Pl. XXXVI, Figs. 7–9, 1920). On close examination, however, the definite conical projection on the inner side of the apex of the cell shows it to be closer to *C. apiculata* (Lemm.) Schmidle (Allg. Bot. Zeitschr. 6: 234, 1900; Smith, *loc. cit.* Pl. XXXVII, Fig. 1). The variety is found along with the species in Lake Erie. During the past summer it was the dominant Crucigenia in Buckeye Lake, near Columbus, Ohio.

Tetrastrum heterocanthum (Nordstedt) Chodat.

(Pl. III, Figs. 38–40.)

Bull. Herb. Boiss 3: 113, 1895; Smith, Trans. Amer. Mic. Soc. 45 (3): 187, Pl. 15, Figs. 16–20, 1926.

This alga occurs quite generally throughout the region. It is particularly common at the mouth of the Maumee River and in a small pond on North Bass Island. The spines are variable. Many are as delicate as those noted by Smith in Iowa, while others are as pronounced as Nordstedt's original illustration.

Scenedesmus bijuga (Turpin) Lagerheim var. **major** nov. var.

(Pl. III, Figs. 42 and 43.)

Colonies curved with 2–8 cells arranged in an irregularly alternating row. Cells ovoid, with smooth walls.

Diameter cells, up to 13μ; length cells, up to 21μ.

The cells of this variety vary greatly in their arrangement. The colonies are always curved. The alga resembles var. *irregularis* (Wille) G. M. Smith (Trans. Wis. Acad. Sci. Arts & Lett. 18 (2): 448, Pl. XXVIII, Figs. 59–62, 1916), but differs in its much larger size.

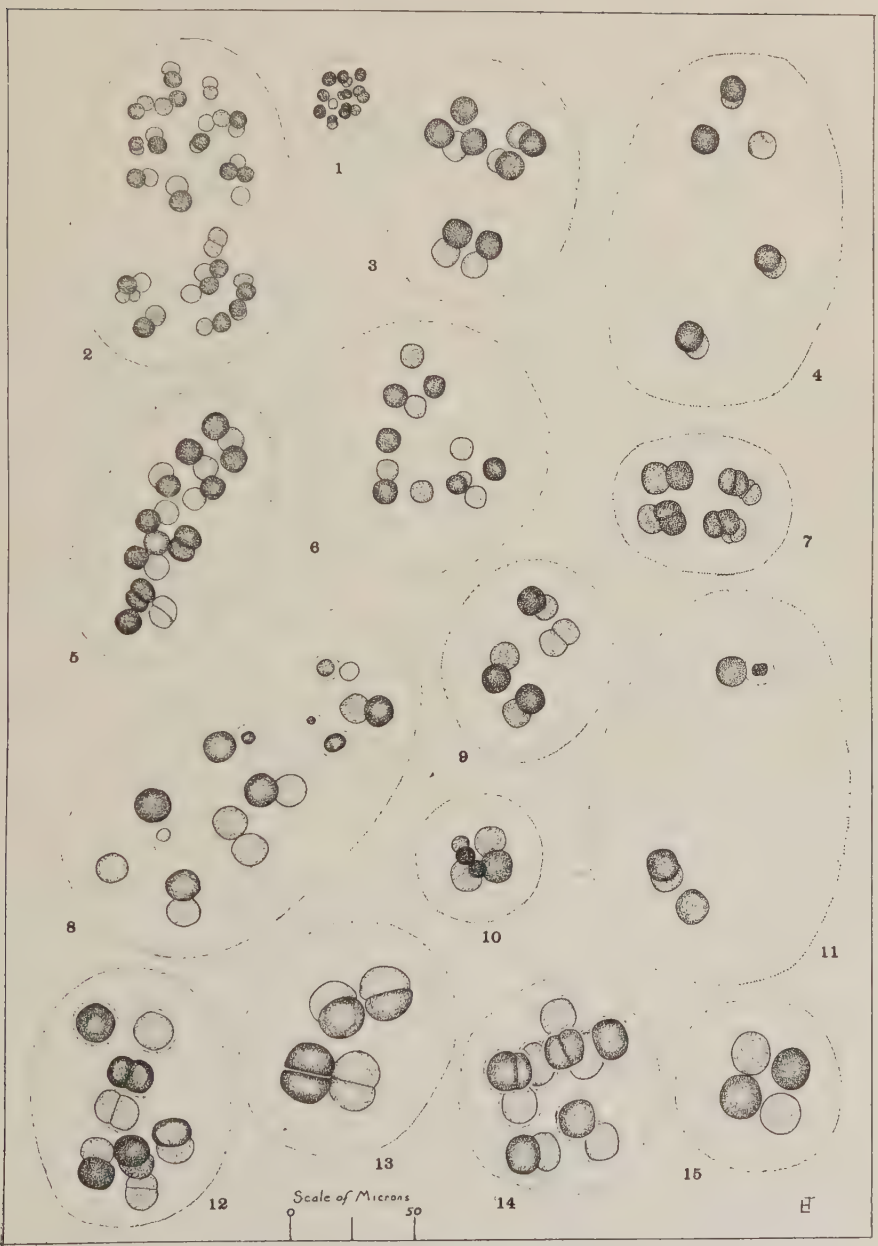

Fig. 1. *Chroococcus limneticus* Lemm. var. *subsalsus* Lemm.
Figs. 2–10. *Chroococcus limneticus* Lemm.
Figs. 11–15. *Chroococcus limneticus* Lemm. var. *purpureus* (Snow) nov. comb. Fig. 11 (=*Chroococcus purpureus* Snow) redrawn from Snow. Fig. 14 (=*Chroococcus limneticus* Lemm. var. *elegans* G. M. Smith) redrawn from G. M. Smith.

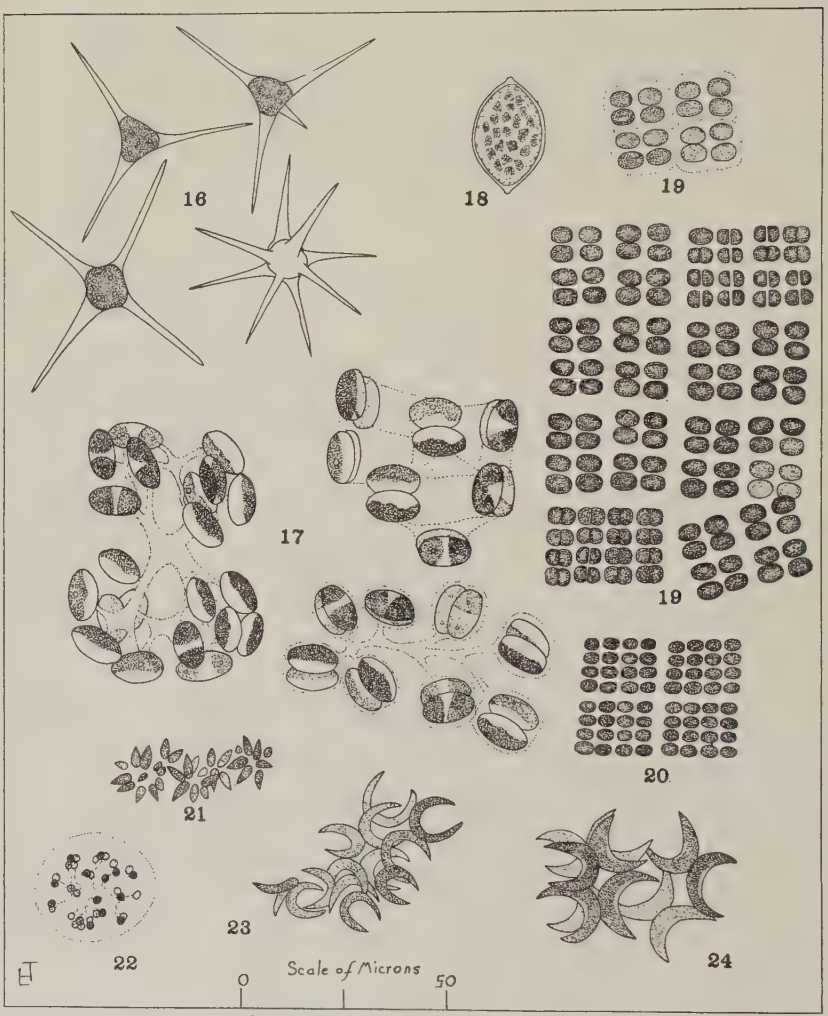

Fig. 16. *Treubaria varia* nov. sp.
Fig. 17. *Dictyosphaerium planctonicum* nov. sp.
Fig. 18. *Oocystis eremosphaeria* G. M. Smith.
Fig. 19. *Merismopedia convoluta* Brebisson.
Fig. 20. *Merismopedia convoluta* Breb. var. *minor* (Wille) nov. comb.
Fig. 21. *Marssoniella elegans* Lemm.
Fig. 22. *Gomphosphaeria lacustris* Chodat. (Redrawn from G. M. Smith.)
Fig. 23. *Selenastrum bibraianum* Reinsch var. *gracile* (Reinsch) nov. comb.
Fig. 24. *Selenastrum bibraianum* Reinsch. (Redrawn from G. M. Smith.)

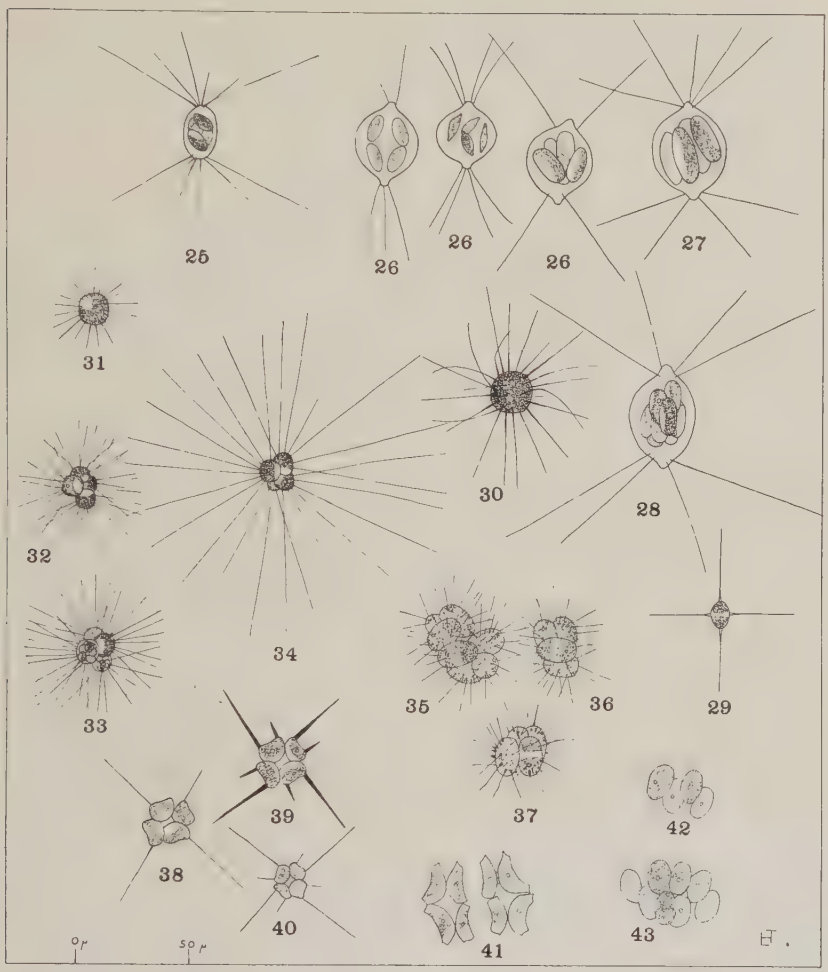

Fig. 25. *Lagerheimia longiseta* (Lemm.) Printz var. *major* G. M. Smith.
Fig. 26. *Lagerheimia citriformis* (Snow) Smith var. *paucispina* nov. nom. (Middle Figure redrawn from Woloszynska.)
Figs. 27 and 28. *Lagerheimia citriformis* (Snow) G. M. Smith.
Fig. 29. *Lagerheimia wratislawiensis* Schroder.
Fig. 30. *Golenkinia maxima* nov. sp.
Fig. 31. *Golenkinia radiata* Chodat var. *brevispina* nov. var.
Figs. 32 and 33. *Micractinium eriense* nov. sp.
Fig. 34. *Micractinium pusillum* Fres. var. *longisetum* nov. var.
Figs. 35 and 36. *Franceia tuberculata* G. M. Smith var. *irregularis* nov. var.
Fig. 37. *Franceia tuberculata* G. M. Smith, showing large tubercles.
Figs. 38–40. *Tetrastrum heterocanthum* (Nordst.) Chodat.
Fig. 41. *Crucigenia apiculata* (Lemm.) Schmidle var. *eriensis* nov. var.
Figs. 42 and 43. *Scenedesmus bijuga* (Turp.) Lager. var. *major* nov. var.

NOTROPIS VOLUCELLUS WICKLIFFI, A NEW SUBSPECIES OF CYPRINID FISH FROM THE OHIO AND UPPER MISSISSIPPI RIVERS.

MILTON B. TRAUTMAN.

A study of the material now preserved in the Museum of Zoology, University of Michigan, and the Ohio State Museum, makes it apparent that several more or less well defined subspecies of the shiner *Notropis volucellus* (Cope) occur in various parts of its range.

In the present paper three northern forms of this species are differentiated and their ranges and habits discussed and defined. It is hoped that the southern forms will be dealt with later. This paper is an extension of the contributions to the status of *Notropis volucellus* and its subspecies which have been made by Hubbs and Green (1928: 375–379) and Hubbs and Ortenburger (1929: 67–70).

The range, variation and habitat of the three forms are as follows:

1. *Notropis volucellus volucellus* (Cope) ranges throughout the Great Lakes drainage, from Lake Champlain to Minnesota, northward to Lake Nipigon in Ontario, and southward to a distance as yet undefined. Specimens apparently referable to *volucellus* proper come from as far south as various parts of the Cumberland and Tennessee rivers systems. Farther south it appears to be represented in the upland streams by at least two different subspecies. The most extreme of these forms, from northeastern Mexico, is being described by Hubbs and Gordon. The southwestern upland form of the United States has been regarded as referable to *N. v. volucellus*, but new material indicates that one or more subspecies may in the future be recognized in this territory.

The typical subspecies is quite consistent in its characters and range, and forms a well defined unit. This is especially true in the northern part of its range beyond the influence of other subspecies. Occasionally, one of the features of this form may fall at one locality, but the ensemble of characters remain. Whenever it comes in close proximity with another subspecies to the south or west, however, this consistency of

characters is lost, and all forms of intergradations between it and the other subspecies can then be noted.

Volucellus proper is very numerous and at times a dominant fish throughout most of its range. It is especially common in the glacial lakes in moderately weedy situations having a silty or mud bottom. As a rule it occurs but seldom in the more strictly terrigenous and exposed portions of these lakes, where its near relative, *Notropis deliciosus stramineus* (Cope), abounds. This condition holds for the Great Lakes themselves where both these species can be found in abundance, especially in the shallower portions.

It is also a common inhabitant within the above-named area in the streams and creeks, living in the quieter pools having a soft bottom of silt or muck, and is not adverse to a moderate amount of submerged aquatic vegetation. Here again it leaves the terrigenous areas with their usually swifter current to *N. d. stramineus*. Towards the southern part of its range *volucellus* proper becomes uncommon or entirely absent in the larger streams and rivers.

2. *Notropis volucellus buchanani* Meek ranges from extreme southwestern Pennsylvania westward to Iowa, south to the Rio Grande and Tennessee. More material farther south from northern Mississippi, Louisiana and Texas will probably show this form to be not uncommon there in the larger streams.

Buchanani does not appear in typical form anywhere in the Great Lakes drainage. But along the Maumee river, and northwestward across Lake Erie to Big Creek, Elgin County, Ontario (Hubbs and Green, 1928: 378), *buchanani* influence is noted, cropping out in isolated places in a most interesting manner. This apparently is a relic from the time when the connection between the Wabash and Maumee rivers still existed.

Since typical examples of *buchanani* throughout the known range show but little variation, this subspecies forms a well defined unit. As pointed out by Hubbs and Green (1928: 378), it is a smaller and much daintier fish than *volucellus* proper; is sharply compressed; has greatly elevated lateral line scales; very large and delicate fins and but few melanophores on the body. The two characters last named suggested the vernacular name "ghost shiner," which has been used by recent authors.

In the northern part of its range, at least, *buchanani* is confined to the lower portions of streams flowing through

lowlands, where they have a southern fauna. Here it is to be found living over a silty bottom in a very sluggish to moderate current, and penetrating freely into weed beds when these are present.

3. A third form, confined to the Ohio and upper Mississippi rivers and the lower courses of their larger tributaries, is now described:

Notropis volucellus wickliffi, new subspecies.

Diagnosis.—This form of *Notropis volucellus* differs from *N. v. buchanani* in growing to a much larger size (reaching the total length of 56 mm. from tip of snout to base of caudal); in having a larger eye; longer and heavier head; much deeper caudal peduncle; larger mouth; lower and more rounded fins with less feeble rays; and in the less elevated and less imbricated scales. In these respects it approaches or agrees with the typical subspecies. From *N. v. volucellus* the new form differs in having slightly larger fins, and in the more anterior insertion of the dorsal. It is differentiated from both *volucellus* proper and *buchanani* in having a relatively larger mouth; deeper caudal peduncle; a heavier head; a more turgid body; less elevated lateral line scales, and a more solidly and evenly stippled dark lateral band on the tail region of the body.

Range.—This form is apparently confined to the larger and deeper waters of the Ohio and upper Mississippi rivers and the lower courses of their larger tributaries. It is represented in the Museum of Zoology by specimens from Ohio, West Virginia, Kentucky, Indiana, Missouri (St. Louis) and Wisconsin.

In the spring vast numbers of this form migrate from the Ohio river up the larger tributaries to spawn, retreating later to the main stream. There is no indication of its occurrence anywhere in small streams or lakes. But very few of the record stations are more than fifty miles away from either the Ohio or Mississippi rivers. The significance of this statement is enhanced when it is considered that all of the hundreds of collections made in the course of the Ohio and Wisconsin fish surveys, containing thousands of specimens of *N. volucellus* from all sections and types of habitats in these two states, have been studied in the preparation of this paper.

Holotype.—A breeding male 48 mm. in length from the tip of the snout to base of caudal, collected by M. B. Trautman and R. B. Foster at the mouth of the Miami river at its confluence with the Ohio river in extreme southwestern Miami Township, Hamilton County, Ohio, on May 25, 1931; Cat. No. 92411,

Division of Fishes of the Museum of Zoology, University of Michigan.

The body is decidedly terete, more so than in *volucellus* proper and much more than in *buchanani*. The width is contained 1.5 times in the greatest depth (taken just before the dorsal). The depth enters 4 times into the standard length of the body; the head 4 times. The orbit, contained 3 times in the length of the head, is quite conspicuous and bulging. Upper jaw 3.5 in length of head.

The caudal peduncle enters 2.25 times in the length of the head. As in other forms of this species, the dorsal fin has 8 rays; the anal 8 rays; and the pelvics 8 rays each. The height of the depressed dorsal fin is contained 2.25 times in the distance from the origin of that fin to tip of the snout. The origin of this fin is equidistant between the tip of the snout and the base of the caudal. The pelvics do not reach to the origin of the anal fin.

Scales 5½–35–4; 3½ to pelvic; 15 before the dorsal. The highest lateral line scales on the exposed fields are only about 2.5 times as high as long.

The general color is silvery. The dusky lateral streak is well developed and is thickly and uniformly stippled, especially posteriorly. Two small black dots mark each scale in the lateral line, one above the pore and the other below, these becoming quite indistinct towards the tail when they merge into the lateral band. The dark margins of the dorsal scale pockets are more diffuse than in typical *volucellus*.

Pharyngeal teeth 4–4 (many paratypes examined), strongly hooked, and with the grinding surfaces but slightly developed or absent.

The nuptial tubercles correspond well with the description given by Hubbs and Ortenburger (1929: 68) for southern forms of the other two subspecies. They cover the head, and are but weakly enlarged between the eyes. They become obsolescent toward the dorsal fin and are generally absent on the sides of the body, except on the lateral line scales. Here they form a vertical row near the base of each exposed field, and another incipient row near the margin. On the pectoral rays they are in one row basally, and in two, rarely three or four, distally.

Numerous paratypes from Ohio and Wisconsin are deposited in the Museum of Zoology of the University of Michigan and in the Ohio State Museum.

Variations and Comparisons.—This subspecies shows a moderate amount of variation, as is to be expected of any form within such a plastic species. Due to this variability, no single character can be found that is everywhere constant. For the certain identification of material of any subspecies of *volucellus*, it is necessary to study several characters, preferably in several specimens.

The shape of the body averages more terete and is more turgid than in *volucellus* proper, and much more so than in

buchanani. This effect is heightened by the heavy caudal peduncle and heavy, rather squarish head.

The width is contained in the depth from 1.50 to 1.75* in the present form; 1.65 to 1.95 in *volucellus* proper; and 1.95 to 2.15 in *buchanani*.

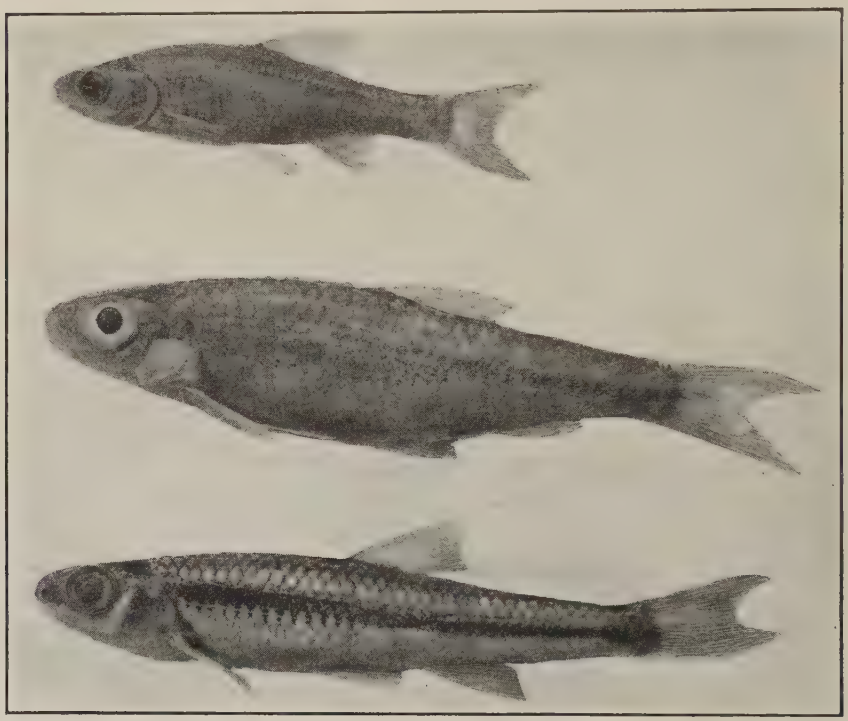

FIG. 1. The three subspecies of *Notropis volucellus*. Upper figure, *N. v. buchanani;* middle figure, *N. v. wickliffi;* lower figure, *N. v. volucellus*.

The depth varies from 3.90 to 4.35 in the standard length in *wickliffi;* 4.6 to 5.0 in typical *volucellus;* and 3.6 to 3.9 in *buchanani*.

The head is contained from 3.9 to 4.1 times in the standard length in the present form, agreeing in this respect with typical *volucellus;* but not with *buchanani*, in which form the head is contained from 3.6 to 3.9 times in the standard length. The whole head is thicker and more heavily built in *wickliffi* than in the other two.

*The usual and not the extreme variations are indicated.

The orbit of the present form is contained 2.9 to 3.3 times in the head; in *volucellus* proper 2.9 to 4.0 times (averaging 3.0 in some northern lakes and 4.0 in others); and in *buchanani* 3.5 to 4.0 times.

The mouth averages larger than in the other two subspecies. The upper jaw is usually contained from 3.4 to 3.6 times in the length of the head; in *volucellus* this measurement ranges from 3.5 to 4.0; and in *buchanani* from 3.9 to 4.1.

In the present subspecies the depth of the caudal peduncle is contained from 2.2 to 2.4 times in the length of the head; 2.6 to 2.8 in typical *volucellus;* and 2.8 to 3.05 in *buchanani.*

The height of the depressed dorsal is contained slightly more than 2.0 times on the average in the distance from the origin of the dorsal to the tip of the snout; in typical *volucellus* this fin is slightly shorter, usually contained 2.3 to 2.6 times in the predorsal length, while in *buchanani* it is longer, being contained 1.6 to 2.1 times in the same interval. The origin of this fin is directly above or but slightly in front of the insertion of the ventral fins; in *volucellus* proper it is inserted a trifle behind the vertical; from the origin of the ventral; and in *buchanani* this fin is decidedly behind the vertical from the origin of the ventrals.

The rows of scales in the lateral line usually number 34 or 35; in *volucellus* proper there are usually one or two more; in *buchanani* one or two fewer.

The scales along the lateral line are less elevated than usual in the species, as the width of the exposed portion averages only 2.5 times in the height of the most elevated scales; in *volucellus* proper this value is about 3.0; and in *buchanani* about 4.0.

The general coloration is not so intense as in typical *volucellus* except along the posterior portion of the lateral band. It is very much more heavily pigmented than in *buchanani.*

Intergrades between *wickliffi* and *volucellus* proper have been found in collections from Ohio and northern Wisconsin; and intergrades between it and *buchanani* from Ohio. Intergrades between *volucellus* and *buchanani* have also been examined.

The occurrence of these intergrades and the high degree of overlapping in all the varying characters in all the forms, calls for treating them as subspecies rather than as species, as one would certainly treat them if only typical examples of each

were at hand. The contrast between extreme examples of these three subspecies is most striking. (See figures).

In as much as *wickliffi* occupies a territory more or less between the centers of the ranges of *volucellus* (subspecies) and *buchanani*, one might be inclined to interpret it as representing intergrades between the two. It does have in fact some intermediate characters such as general paleness, size of the fins and obliquity and terminal position of the mouth. But as evidence of the subspecific distinctness and integrity of the form, it may be pointed out that in other characters it is not intermediate; that in some respects it shows extreme characters (see diagnosis); and that it occupies in abundance and virtually exclusively a very distinct habitat along hundreds of miles of main river course.

Habitat.—N. v. wickliffi has been noted in wholly typical form only in the largest rivers (within the range given above), where these have a silty bottom and practically no submerged vegetation. It is not adverse to turbid conditions or a good current. In the Ohio river and the lower courses of its tributaries, in Ohio at least, this form greatly predominates. It is a deep water shiner, straggling in but few numbers into the shallower portions during the day, especially if the water is clear. Toward evening during the summer months *wickliffi*, together with its close associates, *Hybopsis storerianus* (Kirtland), *Notropis blennius* (Girard) and *Notropis atherinoides* Rafinesque, can be seen coming to the surface in great numbers to feed, or jumping from the water when chased or startled. They appear in large schools in the shallower water at night. Due to its abundance it is undoubtedly of economic importance as a forage fish.

It gives me great pleasure to dedicate this form to my loyal friend, Edward L. Wickliff, who has done much in carrying on and furthering ichthyological research in Ohio.

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A QUANTITATIVE NET-PLANKTON SURVEY OF EAST AND WEST RESERVOIRS, NEAR AKRON, OHIO.

WALTER C. KRAATZ,
Department of Biology, University of Akron.

Introduction.

The Lakes.

Plankton investigations of some of the Portage Lakes near Akron, Ohio, were started by the writer several years ago, but the only systematic work done thus far is the brief net-plankton survey of East and West Reservoirs reported in this paper.

The Portage Lakes consitute a chain of lakes south of Akron. Several of the lakes are in part relics of glacial times, and some are largely of artificial origin. East and West Reservoirs are of the latter type but are old and have long been in good biological condition.

East and West Reservoirs are connected by a long, bent channel, which though shallow, is navigable by small boats. West Reservoir, smaller and narrower of the two, is also connected by a similar but somewhat broader and deeper channel to Turkeyfoot Lake, which, with its tributary lakes, Rex Lake and Mud Lake, is the largest of the group. These named above are on the same level. North from East Reservoir is Long Lake, at considerably lower level. It receives overflow water from East Reservoir principally through an outlet at the northern tip of East Reservoir, but also through Snakey River, close to it. New Reservoir, somewhat higher than Long Lake, has overflow into the latter. Long Lake has a long channel, quite wide in places, flowing northward, joining the Ohio Canal, to which Nesmith Lake is also joined. The map will show the complicated connections of these waters, which need not be described in detail. Summit Lake, still farther northward on the Ohio canal, and within the city of Akron, is not shown on the accompanying map, which is adapted from a "Detailed Map of the Portage Lakes and Vicinity," made by W. V. Quine, 1927.

Period of Collections.

This report is based on collections entirely from these two reservoirs, made from April to October inclusive, 1929. Collections were also made in 1928, but none earlier than June 30,

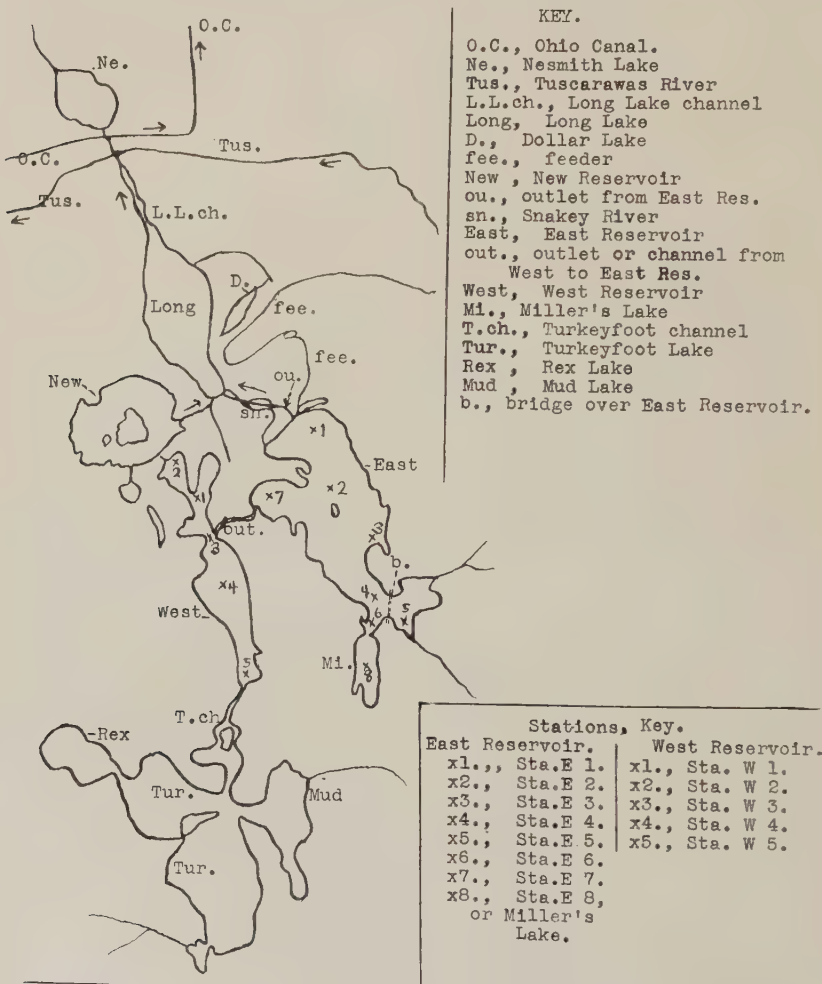

Plate 1. The Portage Lakes, near Akron, Ohio, (Summit Lake omitted), and showing Plankton Stations on East and West Reservoirs.

and unfortunately these were made at different intervals and at different times in the month and especially in the earlier collections, not with the same accuracy and uniformity of

method prevailing for the 1929 collections. It was therefore entirely inadvisable to use any counts of the 1928 plankton in close comparison with detailed counts of the 1929 catches presented in this paper. There would be no accuracy in any averages that could be made of those two years. Only through absolute uniformity of method through a period of years would averages be very significant. It has been impossible to continue the same detailed work since, though it is planned for some future time to make a similar one year survey of the same lakes for a later comparative report if that is found advisable. The delay in this report is due to the dependence upon vacation time for all of the microscopical observations and tabulations. In the general discussion of this paper some use is made of a certain late summer 1928 collection, made by chance at a very similar time as a 1929 collection, the comparison concerning only very abundant organisms.

Purposes of the Investigation.

The investigation had these purposes: to get idea of the chief plankton organisms of these lakes and their relative abundance, to get idea of the seasonal distribution, which in this case is the variation from late April to late October, and to get data on horizontal distribution as seen in different stations, and also on vertical distribution, as far as possible in such shallow waters.

Limitations of the Investigation.

The survey was entirely of the net-plankton, not of the nanno-plankton or minutest organisms. It is quantitative, as plankton organism enumeration was carried on throughout. Results are given as so many organisms per liter of lake water. The method of "standard area units," (see Whipple, 1927, pp. 124–5), in which size of organisms is taken into account may be significant in sanitary analysis, but does not appeal to one listing organisms for a biological survey. There is here no bulk measurement of so many cubic centimeters of plankton per cubic meter of water, etc., as expressed by Whipple in his discussion of "standard cubic units," (Whipple, 1927). No weight determinations were made of plankton or of organic matter of the plankton, as recently carried out by Birge and Juday (1922), and others. There was no attempt to make

estimates of the productivity of the lakes as for instance of so many grams of organic matter per cubic meter of water.

In connection with this biological investigation no chemical analyses of the water were made, and no physical measurements, except that surface water temperatures were taken. No equipment was available for taking temperatures in deeper water.

The two lakes are shallow, and it seems from a considerable number of soundings made at selection of stations, that depths of over 15 or 18 feet in times of high water, must be few. Large areas of the middle of the lakes may not be over 10 feet deep. Undoubtedly both lakes are shallower than Turkeyfoot Lake.

Acknowledgments.

Thanks are due the Division of Conservation of the Ohio Department of Agriculture, and particularly to Mr. E. L. Wickliff, Chief of the Bureau of Research of that Division for material help in the investigation. The Division purchased the Birge closing, quantitative tow net for the writer, and vials and bottles. Also an outboard motor boat belonging to the conservation warden of the district was at my disposal. The microscopic equipment used and the counting cell belong to the Department of Biology, University of Akron.

I also wish to thank the following for identifications of some plankton organisms: Dr. L. H. Tiffany, for numbers of algæ determinations early in my collections; Dr. Lowell E. Noland, for the identification of the Protozoan Codonella; Mr. Frank J. Myers for identification of rotifers, especially Synchaeta and Anapus, (which he pointed out is now Chromogaster), and in fact for identification to species and variety of all rotifers in some samples sent him. I require only generic names of the commoner forms. He also used the newer genus name Keratella for the older Anuraea, which I venture to retain however, since it will be more readily recognizable by readers. I also wish to thank Prof. Chancey Juday for help in response to many questions on plankton methods I put to him, and likewise Dr. Stillman Wright and Mr. Wilbur Tidd for their replies to questions on their plankton methods.

Methods and Apparatus.

Collecting.

Collections were made with a Birge closing, quantitative, plankton tow net, made by Mr. J. P. Foerst of Wisconsin. The silk bolting cloth was of the very fine mesh, old number 20, new number 25. The collecting method is the old one dating from 1882 (Henson 1887). No other collecting device was used. For this general method see chapters on collecting in Ward and Whipple (1918), and Whipple, (1927).

In figuring the volume of water strained by the net the following results were obtained. The upper net ring diameter being 10 cm., the area of collecting surface, was ($r^2 \times \pi$), or $5^2 \times 3.1416 = 78.5$ sq. cm. All hauls were made 1M. in length. Hence the water column traversed was a cylinder, 78.5×100 cm. = 7850 c.c. or 78.5 liters.

But any fine mesh tow net strains less water actually than the column traversed, as has been noted by various investigators. "The whole column of water through which the net passes is not strained however, since the straining part of the net offers some resistance to the passage of the water and a certain portion of it is pushed aside and not strained. This makes it necessary to determine the efficiency of the net, or the coefficient, which serves as a factor for calculating the total number of organisms in the column of water." (Birge and Juday, 1922, p. 8). And these investigators point out that in addition variations in the quantity of the plankton causes slight irregularities in the actual water strained and that the aging of the net does likewise due to more and more clogging of the net. Mr. Juday supplied the coefficient of the net, which is 2; that is the number of organisms secured in any catch would have to be multiplied by two. Birge, in an early paper, (1896) discussed the problems of net coefficients.

The speed of hauling the net alters the coefficient slightly. In an earlier report, Juday (1896) pointed out that a net drawn 77 cm. per second strained one-half of the water traversed so that the efficiency was 50% or the amounts of plankton secured would have to be multiplied by two. Under other net conditions this might vary. Through some initial trials the writer secured some such speed and the "feel" of the pull of this sort of haul, which is not very fast and can be carried out,

was so impressed that a rather uniform haul could be maintained thereafter.

Hauls of the net were not as difficult as they would be in larger bodies of water where there was more wave action. Only seldom was there enough wave motion to make it difficult to read the exact depth on the calibrated line of the net. Surface records so-called were made by hauling the net one M. horizontally, gauged by a M. marked off at edge of boat, holding the net rim just completely submerged in the water.

The collections were made at 5 stations on West Reservoir, and 8 on East Reservoir. These are designated on the map, (Plate I) and on my records as W1 to W5 and E1 to E8. Of the 8 on East Reservoir, the last or E8 is in a tributary Lake, Miller's Lake. For some purposes in this work this is regarded as a separate lake. Station E1 was out in the middle of the northeast arm of the lake, one of the deeper stations; a 3-4 M. haul could be secured there. E2 was in the center of the largest part of the lake, which was shallower however owing to its proximity to a sandbar, and allowed no deeper haul than 1-2 M. Later some deeper spots were discovered some distance off from this station. E3 was nearer shore in a cove, but allowing also a 1-2 M. haul. E4 was near the center of the channel between the two larger parts of the lake, and quite deep, though not allowing quite for a 3-4 M. haul. E5 was in a shallow area not far from shore in a smaller lagoon-like area of the lake, but this part is not cut off from the larger lake, the apparent cut-off on the map being a bridge. E7 was in the middle of the smaller or northwest arm of the lake; and was deep enough for 3-4 M. haul. E8 was in the center of Miller's Lake, tributary to East Reservoir. It was also deep enough for a 3-4 M. haul. On West Reservoir, W1 was in deep water a short distance from a promontory separating the two northern arms of the lake. A 3-4 M. haul could be made there. W2 was in the upper, middle part of one of these arms, and also deep enough for a 3-4 M. haul. W3 was in the middle of the narrow part of the lake where the channel from East Reservoir meets West. W4 was in the center of the largest part of this lake, but an area not deep enough to yield a 3-4 M. haul. W5 was near the southern end of the lake, in the center near that end near the channel which joins Turkeyfoot Lake.

All stations were distinctly off shore enough to escape littoral conditions. No collections were made where surface

vegetation like Lemna or Wolffia occurred. No collections were made where the net would in making the actual measured haul upward, be in any dense bottom vegetation. So few depth samples could be secured because always the depth has to be such as to allow the bucket to be free from bottom mud, or nearly 1 M. more than greatest depth sample actually used. Thus only three stations out of eight on East and two stations out of five on West were deep enough for a 3-4 M. haul. In all the rest no deeper haul than 1-2 M. was secured. In all of the stations there was this 1-2 M., haul except at E5, where only the surface haul was made. Late in summer when the water depth decreased, station E5 was moved out farther into the lake.

Hauls of merely one meter may seem short, but longer ones were not feasible if more than one vertical sample was to be secured from such shallow water. There was hope of recognizing some differentiation in water samples, collected at surface and at depths 1-2 M. and again at 3-4 M. The intervening meters of water were not sampled, or the water samples were made discontinuous in hope of showing any existing differences distinctly.

Collections were made on April 20, May 25, June 21, July 20, Aug. 21, Sept. 21, and Oct. 26.

All collections were made in daylight at approximately same time of day. The collections from all stations requiring a minimum of three and one-half hours, were always made in the same sequence, so that even though there were delays in starting or frequently during the work, the light conditions were not materially different in the different trips, except as seasonal or weather differences brought about, and on all collecting days weather was clear except for the April collection when the sky was overcast and a light drizzle fell part of the time.

The plankton water samples were collected in vials from the bottom of the net bucket. A small, uniform amount of water from a wash bottle was used to help wash organisms into the vial. The samples then varied usually between 10 and 15 or maybe 20 c.c. The exact size of sample at collection is of no significance, provided it is made of uniform size with others by distilled water in subsequent work. About 1-2 c.c. of strong formaldehyde was put into each vial before collecting the lake water into it.

Not all limnoplankton can be secured with the plankton net, as a host of the smallest organisms, the nannoplankton, would escape unless accidentally held in masses with larger organisms. Some organisms observed and even a few counted in this work, may seem to border on this nannoplankton group. But all the smaller organisms included are usually listed as being within net-plankton limits, and the same genera are thus listed for instance by Birge and Juday (1922). These smallest ones listed in this paper occur in such large numbers and with such seasonal variation as is considered normal, that it seems certain that appreciably none were lost through the net or that all were collected in the same proportion as larger organisms.

Microscopy.

The microscopic work was done at intervals, chiefly during summer vacations. Only a part of some 1928 collections were examined, at whatever concentration they were at time of collection, and for most samples counted there was too great a concentration of organisms. In all the work on the extensive 1929 collections, varying small amounts of distilled water were added to the plankton water samples, to make the working plankton sample size a number of c.c. which would be a small decimal or simple fraction of the amount of lake water strained by the net. This would make calculations much simpler later than to take some seemingly simple figures as 10 or 20 c.c. for the working sample. Since the theoretical water column of a net haul was 7850 c.c., a sample size of 7.85 c.c. would have been theoretically good, or on the same basis, a sample size of half that would have immediately given in 1 c.c. examined the number of organisms in a liter of lake water, because the 50% net efficiency would actually collect half the organisms, or organisms of half that actual lake water, and multiplying by 2 would give the actual numbers for the 7850 c.c. But such samples are all too small for practical reasons, such as inability to measure accurately in graduate cylinder, and too great a concentration of organisms. By making concentrate 15.7 c.c. and also in many cases 31.4 c.c. then by a simple multiplication of the number of organisms in 1. c.c. of the concentrate, by 4 or by 8 respectively, gave the number in one liter of lake water. In each case the total concentrate was well stirred in a beaker and 1 c.c. of it pipetted into a Sedgwick-Rafter counting cell, (50 × 20 mm., and 1 mm. deep).

Microscopic examination was done under a Spencer low power binocular, and for more magnification under compound microscope, 16 mm. objective. The binocular was used with its highest magnifying power, × 46, for examining the entire cell contents. The cell was moved across the stage against a ruler held by clips, and then adjusted the correct distance for another crosswise movement, a definite number of times until the entire 20 mm. width was covered. Complete counts of all larger organisms and indeed for types down to the smallest recognizable with this binocular, were made. Many more were counted in the whole cell than first planned, but these whole counts bring more accurate results than the counts of smaller parts with calculations, as is necessary for the smallest organisms. Thus not only Entomostraca and Rotifers were fully counted, but such as the Protozoan Ceratium and even the filaments of the algal colony Anabaena.

The compound microscope was used for distinguishing and counting smaller planktonts, or those of too great an abundance to count in entire cell. A 16 mm. objective and 7.5 ocular were used. Higher magnifications were not needed for this work, nor was time taken for thin mounts of any planktonts. The Whipple ocular micrometer was used in counting. With the above combination of lenses a tube length of 184 mm. was necessary to have the large square of the Whipple micrometer equal 1 sq. mm. on the stage. The organisms in a cube covered by such square were counted completely. Twenty such fields scattered rather regularly over the entire cell (equal to 1000 such small fields) were taken and examined fully. The total of counts in 20 fields for any organisms multiplied by 50 gave the total number in 1 c.c. of the concentrate, or counting cell.

This standard method of counting and then multiplying to get total numbers, may result in errors of rather large size, if the numbers of organisms involved is rather small, though only neglegible errors if the numbers are large. This was verified in many cases on organisms of such size that they could be counted under binocular, as rotifers Ceratium, Anabaena filaments, as well as Cyclops eggs, Nauplius larvæ, etc. The method of counting all individuals was compared with the other method and discrepancies noted. Actual examples will not be detailed here, except to note that in several instances cases of Ceratium and also rotifers Anuraea and Polyarthra, were found to have when 20 fields were counted and multipli-

cation made, far too high a number assigned, proven by the actual counts of same samples under binocular, in such cases where the numbers were of the order of 100 individuals for entire cell, though when the actual numbers were of an order of 1000 or thereabouts, no real discrepancies occurred.

This matter must be obvious to most plankton investigators, but has not been stressed much in reports. To avoid as far as possible considerable errors in numbers, as large a number of plankton kinds as could be recognized under the binocular, were fully counted for the entire cell, involving often very tedious work.

No complete list of plankton has been attempted. Only limnetic plankton identified to genus and of such occurrence that at least a few would be encountered from time to time were considered for the actual plankton counts, though if a very rare form were large and identifiable, record was kept of it. No estimates were made of partly disintegrated forms.

Discussion of Plankton Collections.

Plankton Kinds and Limitation of Data in Tabulations.

When all plankton counts were made the 1929 collections data were so tabulated that there were 14 tables, one for each monthly collection and each lake, each containing the data of number of planktonts of every kind regularly counted, per liter of lake water, separately for each station and for surface and two depths. Only a few plankton types of large size but very rarely encountered were omitted. These tables are too bulky for presentation. They would show all the minor variations of stations. But since many of the organisms were not commonly found, there would be many blank spaces for absence of various kinds any one month from some or all stations.

The rarely occurring genera that may be noted briefly here included: the Protozoan Vorticella, occurring in small numbers at one station in three collections, the Cladocera Scapholebris and Camptocercus each occurring at only one station in one collection. Also the Ostracod Cypris was found only twice in very small numbers, a surprising rarity considering their abundance in food of some minnows taken in an earlier year, from the same lakes (Kraatz, 1928, and Cassidy, Dobkin and

Wetzel, 1930). Hydra was found in just one collection at one station June 21, (one specimen in surface sample and 4 at 1-2 M.). This meant only 4 Hydra at most in the entire concentrated sample, or less than one per counting cell sample. Presence of this form in the limnetic zone cannot be accounted for. Rarer rotifers included Anarthra, occurring twice in small numbers, and a few others not then identifiable to genus by the writer. Mr. Myers identified to species all rotifers in a few vials sent him, and indicated them as rare, few, common, or abundant. Those he marked rare are omitted from tables, those marked few, referred to (to genus) below, are also omitted from the shortened tables, and only the common and abundant ones are listed to genus in tables in this paper.

Counts were kept of eggs of rotifers, and Cladocera, and of the genus Cyclops. The eggs, often were numerous, especially of Cyclops and rotifers, were however eliminated from the tabulations. A total of 37 distinct genera remain in these longer tables of plankton kinds.

To present more concisely, and at the same time quite fully all the significant comparative data, 20 of the 37 genera were selected on the basis of being the most representative planktonts of these lakes, and either abundant or common, or if seemingly in small numbers, found rather uniformly in many monthly collections. These tabulated (tables 1–7) on basis of monthly collections, show the differences between the lakes, and retain the surface and depths differences but are averages of the several stations on a lake at any one level. Thus at West Reservoir, 5 stations were averaged, at east Reservoir 7 stations were averaged, but No. E8, which is Miller's Lake, tributary to East, was kept distinct.

The plankton types omitted from the tables 1–7, and which were on the whole not as abundant as any included, occurring as very few here or there or in a few cases abundant in one monthly collection, are here listed: the blue-green algæ Merismopoedia, and Oscillatoria, (really abundant in the May collection, and not noticed otherwise); the green algæ, Westella, Staurastrum, Mougeotia; the flagellates (plant or animal) Euglena, Phacus, Synura, Pandorina, Eudorina, and Mallomonas, (which occurred in small numbers in quite a few collections); the Protozoa Arcella and Epistylis; the rotifers Notholca, and Anapus (now called Chromogaster, as Myers pointed out); and the Cladocera Chydoris and Ceriodaphnia.

Since the seasonal distribution is one of the main objectives, the monthly variations were brought together in close comparison, (tables 8–10), one table devoted to each lake, including a separate one for Miller's Lake, and in each case furthermore the plankton number represents an average of all three levels,

TABLE 1.

APRIL 20 COLLECTIONS. COMPARISON BETWEEN LAKES AND OF DEPTHS OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.
Coelosphaerium	3								
Microcystis	1								
Anabaena	3								
Aphanizomenon									
Melosira	20,920	20,160	21,800	19,315	15,733	8,200	1,000	1,000	100
Synedra	13,280	10,840	8,660	8,671	4,300	3,200	3,200	1,200	1,200
Asterionella	18,400	19,840	13,000	72,885	54,400	24,800	22,200	9,600	9,600
Fragilaria	1,880	800	1,200	115	171				
Pediastrum	89	17	12	15	15	10			
Dinobryon						2			
Ceratium	5	6	2	1	1		4	4	
Codonella	78	114		850	582	644	76	4	
Polyarthra	744	619	734	916	526	320	368	248	300
Anuraea	2,231	1,937	892	632	437	282	1,040	1,016	
Synchaeta	112	71		33	306	2			
Asplanchna	6	2		1			4		
Nauplius	124	111	290	242	115	70	72	72	108
Cyclops	102	82	106	72	55	62	96	108	304
Daphnia	9	10	14	15	16	12	12	4	16
Bosmina	27	30	16	13	38	8	4	12	
Surf. Tempt.	11° C.			11° C.			11° C.		

surface, 1–2 M. and 3–4 M. This method of presenting the summaries and comparison was chosen rather than graphs, because while graphs are graphic, but only obviously so when arithmetical plot is used, the wide range in numbers for some organisms, as in an extreme case the diatom Asterionella, of hundreds of thousands in one month and then a fluctuation of

from several thousands to even a hundred or less for all other months, would require a peak of relatively enormous height in the graph, or most of the other fluctuations of practically microscopic height. Many of the plankton graphs would be more or less of this sort. Or to show fully the main fluctuation,

TABLE 2.

MAY 25 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.
Coelosphaerium	30	57	384	25	24	44		32	
Microcystis	27	34	8		60				
Anabaena	464	968	452	299	246	132	32	8	8
Aphanizomenon									
Melosira	7,040	20,720	800	9,829	15,066	12,600	3,800	4,400	8,000
Synedra	7,520	10,080	200	48,600	46,266	30,400	41,200	27,600	24,400
Asterionella	99,160	209,841	217,400	204,228	460,700	304,400	302,800	396,000	380,000
Fragilaria	960	1,680	1,400	182	400	800	800	1,200	800
Pediastrum	42	50	56	51	105	72	16	56	64
Dinobryon	29,920	38,640	10,804	21,886	21,266	7,200	58,400	46,800	20,000
Ceratium	54	98	40	6	27	16	16	40	64
Codonella	6	30	15	26	85	280		16	
Polyarthra	1,560	1,885	428	268	760	308	12,000	1,840	1,440
Anuraea	3,011	3,775	1,213	896	2,108	776	2,368	3,584	1,984
Synchaeta	5	18	8						
Asplanchna	88	78	12	59	222	96	56	200	104
Nauplius	66	181	76	12	147	36		96	48
Cyclops	14	22	4	3	10		8	8	80
Daphnia	6	38	14	1	18	8		16	64
Bosmina	142	95	4	9	48	24	7	16	16
Surf. Temp.	18.5° C.			18° C.			18° C.		

the minor ones would have to be disregarded. If all 20 organisms were fully graphed, more space would be needed than in these tables, as few could be put on one graph.

Of all 20 kinds in these tables, possibly Codonella is least known to readers, to those not versed in Protozoology. It can be misidentified, as first by the writer, as a Difflugia. It

is a Ciliate with lorica. Codonella belongs to sub-order Tintinnoidea or Tintinnoinea, of the order Oligotricha, which is itself placed by some writers within order Heterotricha. The group outside of a few fresh-water types is marine and pelagic.

TABLE 3.

JUNE 21 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.
Coelosphaerium	208	53	1,750	69	79	332		24	136
Microcystis	136	123	324	72	16	44			16
Anabaena	16,560	12,000	68,200	19,200	8,933	19,000	504	4,800	1,200
Aphanizomenon	3,680	4,960	3,900	28,971	17,533	10,000	2,000	4,400	2,000
Melosira	400	480	800	1,027	666	1,200		1,200	12,800
Synedra	80	320		57	66				1,200
Asterionella	960	649	2,600	6,114	4,933	10,400		4,400	9,600
Fragilaria	320	565	200	914	800	1,200		400	800
Pediastrum	27	41	64	153	114	95	8	160	224
Dinobryon		80	2,400	269	221	68	800	5,200	12,800
Ceratium	419	1,008	1,136	459	421	72	96	1,696	976
Codonella		16		5	9	16		48	
Polyarthra	177	190	24	429	269	24	24	144	80
Anuraea	147	307	120	273	202	68	160	968	600
Synchaeta				67	32	44	32	32	
Asplanchna				3					
Nauplius	70	128	8	41	41	84	32	160	152
Cyclops	10	27	32	7	4	12	8	40	112
Daphnia	5	6	32	12	25	20		56	72
Bosmina	10	64		17	5	8	8	352	
Surf. Temp.	27° C.			27° C.			27° C.		

Horizontal Distribution.

There is first of all no distinct or uniform difference whatever in fauna and flora of East and West Reservoirs, or East Reservoir and its tributary, Miller's Lake. While there was for some planktonts a difference in numbers of some magnitude, this would be a much greater number of individuals from

stations of one lake at one collection and often from the other lake at another collection. The chief instances of fairly well-marked differences in numbers of individuals of the two lakes, and in this case Miller's Lake is often counted in with East Reservoir, were the following. Coelosphaerium was commoner

TABLE 4.

JULY 20 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.
Coelosphaerium	400	454	600	23	53	60			
Microcystis	6	75	8	289	4	8			
Anabaena	7,120	3,600	5,200	1,775	2,341	3,200	184	320	240
Aphanizomenon	1,440	960	800	1,257	933	200		800	400
Melosira	6,240	4,960	5,800	1,371	1,333	600			
Synedra	1,040	1,040	1,000	10,143	9,466	2,400	400	400	
Asterionella				114					
Fragilaria			200		133				
Pediastrum	69	56	52	20	20		24		8
Dinobryon	960		400						
Ceratium	201	318	428	1,229	682	216	64	72	88
Codonella	2	6	20	1	5	20			40
Polyarthra	245	283	140	576	500	264	88	112	128
Anuraea	856	200	244	259	313	124	80	120	200
Synchaeta	2	10	56	182	177	28	120	88	136
Asplanchna		2							
Nauplius	42	109	76	58	144	120	8	16	112
Cyclops	3	21	60	2	10	8		8	
Daphnia	2		12						
Bosmina	2	3							
Surf. Temp.	24.5° C.			24° C.			24° C.		

in West Reservoir than in East in May, June, Aug., Sept., and Oct.; Microcystis commoner in West than in East in June, Aug., Sept., Oct.; Anabaena was also more abundant in West than East in all of collections, May to Oct.; but Aphanizomenon was commoner in East Reservoir in June and Aug., but commoner in West in Sept., and Oct. Melosira was found more

abundant in West than in East in April, July, Aug., Sept., and Oct. Synedra was commoner in West than in East in April, Aug., and Oct., but commoner in East May, July, Sept. Asterionella was more abundant in East Reservoir than in West in all months except Oct. Fragilaria was commoner in

TABLE 5.

AUGUST 21 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.
Coelosphaerium	318	752	104	6			8	24	48
Microcystis	75	85	44						
Anabaena	9,976	6,200	5,700	607	759	992	240	56	
Aphanizomenon	3,200	2,880	5,200	1,886	933	600			
Melosira	6,320	7,600	10,800	1,257	1,600	800	400		
Synedra	1,680	1,920	4,000	1,086	400	400			
Asterionella		80	400			200	400	400	2,000
Fragilaria									
Pediastrum	19	3	32	1	4	4			24
Dinobryon	240						1,600		
Ceratium	14	6	8	1					8
Codonella	5	6	4	6	3	8		8	
Polyarthra	391	326	316	88	155	32	112	144	80
Anuraea	214	313	428	49	90	80	40	144	112
Synchaeta	298	168	96	37	37	12	40	64	64
Asplanchna	19	14	8	5	1				
Nauplius	149	126	80	9	41	28		32	48
Cyclops	8	16	44	5	8	8			
Daphnia									
Bosmina	21	22	24		3	8			
Surf. Temp.	23.2° C.			23° C.					

West than in East, April, and May, but commoner in East in June. Dinobryon showed a greater number by far just in Miller's Lake than in rest of East or West in May, June and Aug., but a greater number in West in July. Codonella showed a greater number in East Reservoir than in West in April, but with few differences otherwise. Polyarthra showed greater

numbers in Miller's Lake in May, greater in East Reservoir in July, but in West in Aug. Anuraea showed greater numbers in West than in East in April, July, Aug., and Oct., but greater in Miller's Lake than the others in June. Synchaeta occurred in greater numbers in East than in West in April, June, and July,

TABLE 6.

SEPTEMBER 21 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.
Coelosphaerium	700	360	240	38	27		16	16	
Microcystis	225	189	40	15	3				
Anabaena	8,078	3,936	2,980	982	584		24	8	
Aphanizomenon	1,040	320		343	138				
Melosira	20,400	18,480	15,400	13,143	13,800	8,400	400	400	800
Synedra	1,200	160	200	857	1,000	800			
Asterionella	80	80		857	400	2,800			
Fragilaria									
Pediastrum	27	27	44	13	15				16
Dinobryon				57					
Ceratium	19	10	4	15	9	16			
Codonella	18		12	59	60	160			
Polyarthra	341	122	72	158	168	96	72	80	48
Anuraea	213	101	24	109	93	32	136	144	144
Synchaeta	242	181	48	249	303	24	136	136	128
Asplanchna									
Nauplius	176	32	36	90	75	24	24	40	40
Cyclops	19	19	36	21	28	16	8	8	56
Daphnia	3								8
Bosmina	9			6	3				8
Surf. Temp.	17.5° C.			18° C.			18° C.		

but greater in West in Aug., and Oct. These are probably differences of little significance. For other organisms and other months for the above, there were slighter differences. All can be traced on the tables, as the data for the lakes is kept distinct.

As for differences in numbers of individuals in a series of stations on the same lake, few differences would be expected except where the body of water has various distinct bays or parts, well sheltered or isolated one from another. East Reservoir shows few such areas, and no significant station

TABLE 7.

OCTOBER 26 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.	Surface	1–2 M.	3–4 M.
Coelosphaerium	110	184	120	3	11				
Microcystis	30	40	48	5	4				
Anabaena	217	371	148	53					
Aphanizomenon	80	266		57					
Melosira	12,560	23,600	15,200	2,743	4,000	2,400	400	800	800
Synedra	1,280	2,266	800	1,086	600	400	400		
Asterionella	4,776	12,666	10,400	114	267		400	1,600	400
Fragilaria									
Pediastrum	23	40	16	7	9			8	16
Dinobryon									
Ceratium		2			1				
Codonella	86	121	76	67	85	80	30	48	48
Polyarthra	205	283	100	131	156	96	64	320	160
Anuraea	235	466	140	103	132	96	32	208	120
Synchaeta	224	283	108	71	176	152	24	8	24
Asplanchna	2			27	36	16	16	24	32
Nauplius	50	74	48	62	71	64	16	72	56
Cyclops	16	18	12	14	15	8		8	16
Daphnia	1								
Bosmina	3	5		7	8			8	
Surf. Temp.	11.5° C.			11.5° C.			11.5° C.		

differences, only countless minor chance variations. West Reservoir does show a number of well marked parts. Nevertheless there were no real differences of import to be noted among the stations. This is in accord with findings in other studies. It was noted for instance by Marsh (1903) that horizontal distribution is very uniform. But one discernible

difference holding for both lakes must be mentioned. Somewhat greater numbers of individuals of very many kinds were noted in northern parts of the lakes, (stations 1 and 7 on East and stations 1 and 2 on West Reservoirs). This seemed to be caused in part by winds, though in East Reservoir an effective cause would seem to be the flow towards the outlet at that northern end of the lake. In both lakes winds were frequently

TABLE 8.

Monthly Distribution of Chief Net-plankton Organisms of West Reservoir.

Names of Organisms	April 20	May 25	June 21	July 20	Aug. 21	Sept. 21	Oct. 26
Coelosphaerium		157	670	485	391	433	138
Microcystis		23	528	30	68	151	39
Anabaena		628	32,253	5,307	7,292	4,998	249
Aphanizomenon			4,180	1,067	786	453	346
Melosira	21,293	13,853	560	5,667	8,240	18,093	17,120
Synedra	10,927	7,267	133	1,027	2,533	520	1,782
Asterionella	17,080	175,467	1,403		160	53	9,281
Fragilaria	1,293	1,346	362	67			
Pediastrum	39	49	44	59	18	33	26
Dinobryon		26,455	827	453	80		
Ceratium	4	64	854	315	9	11	1
Codonella	64	17	5	9	5	10	94
Polyarthra	699	1,291	130	223	344	178	196
Anuraea	1,686	2,666	191	433	318	113	280
Synchaeta	61	10		23	185	157	205
Asplanchna	3	59		1	14		1
Nauplius	175	108	69	76	118	81	57
Cyclops	97	13	23	28	23	25	15
Daphnia	11	19	14	5		1	
Bosmina	24	80	25	2	26	3	3

seen to be, as seen also in wave action, towards the north and northeast. The station differences as indicated above, have been merged in the averaging necessary to produce the condensed tables.

Vertical Distribution.

Due to the shallowness of the water, little data on the vertical distribution of plankton can be secured, or in other words there will be little chance for differences in the small

depths available in these lakes. The factor of different light intensities enters here in but a small way, except as turbidity governs that. The waters are of average turbidity. No exact measurements were made. The vertical differences show no uniformity that will allow any definite conclusions. The data can be seen in the tables (1–7) where the numbers for surface and depths are given fully, though averaged for all stations

TABLE 9.

MONTHLY DISTRIBUTION OF CHIEF NET-PLANKTON ORGANISMS OF EAST RESERVOIR.

NAMES OF ORGANISMS	APRIL 20	MAY 25	JUNE 21	JULY 20	AUG. 21	SEPT. 21	OCT. 26
Coelosphaerium		31	160	453	2	22	5
Microcystis		20	44	100		6	3
Anabaena		226	15,711	2,439		522	18
Aphanizomenon			18,835	797	1,139	161	19
Melosira	14,416	12,498	964	1,101	1,219	11,781	667
Synedra	5,390	8,422	41	7,334	629	886	133
Asterionella	50,695	323,109	7,149	38	67	1,352	800
Fragilaria	95	461	971	44			
Pediastrum	13	76	121	13	3	9	8
Dinobryon		16,781	186			19	
Ceratium	1	16	317	709		13	
Codonella	692	130	10	9	6	93	42
Polyarthra	587	445	241	447	92	124	181
Anuraea	450	1,260	181	199	73	78	120
Synchaeta	114		48	129	29	192	19
Asplanchna		125	1		2		24
Nauplius	142	65	55	107	26	63	48
Cyclops	63	4	8	7	7	22	8
Daphnia	14	9	19				5
Bosmina	20	27	10		4	3	3

at each level. Naturally wider discrepancies for different depths occurred at some stations, but these were compensated for by data from other stations.

Seasonal Distribution.

The monthly variation or distribution, from April to October, is shown on tables 8–10, on which all depths and stations of a lake are averaged together. Summer conditions are most fully

demonstrated, but an idea of spring conditions with spring pulses for certain groups and also of autumnal increases and decreases is presented. No winter records are available. The summer seasonal record for the year 1929 may not be entirely representative, but it appears to the writer as if the only unusual thing was the somewhat abnormally lowered temperature at certain brief periods in both July and August, covering

TABLE 10.

MONTHLY DISTRIBUTION OF CHIEF NET-PLANKTON ORGANISMS OF MILLER'S LAKE.

NAMES OF ORGANISMS	APRIL 20	MAY 25	JUNE 21	JULY 20	AUG. 21	SEPT. 21	OCT. 26
Coelosphaerium		11	53		27	11	
Microcystis			5				
Anabaena		5	2,168	248		11	
Aphanizomenon			2,800	400			
Melosira	700	5,400	4,666		133	533	667
Synedra	1,867	31,067	400	267			133
Asterionella	13,800	359,600	4,666		933		800
Fragilaria		933	400				
Pediastrum		45	131	11	8	5	8
Dinobryon		41,733	6,267		533		
Ceratium	3	40	923	75	3	5	
Codonella	27	5	16	13	3		42
Polyarthra	305	5,093	83	109	112	67	181
Anuraea	685	2,645	576	133	99	141	120
Synchaeta			21	115	56	133	19
Asplanchna	1	120					24
Nauplius	84	48	148	45	27	35	48
Cyclops	169	32	51	3		24	8
Daphnia	11	27	43			3	5
Bosmina	5	13	120			3	3

the collecting dates in both these months. That is for some days or a week a lower temperature gradually lowered the water temperature at both these times. The one effect that was probably produced was the holding in check of the blue-green algæ, so that there was no very noticeable water-bloom, as has been observed and verified in small samples in other years (1928 especially) to be caused entirely by a flare-up of the same blue-green algæ shown most abundant in this investiga-

tion. Hence a relatively smaller number of these algæ in July and in August, and maybe September, would be the only difference between this record here presented and conditions in many other years.

The Monthly Distribution of the Plankton Groups.

The Cyanophyceæ (blue-green algæ) were at their maximum abundance in June, with a decrease in July and about the same numbers in August, with a continued decrease thereafter. There were none found in April and few in May.

The genus of greatest abundance is Anabaena, and it stood first in abundance of individuals at all times except in one flare-up of Aphanizomenon in East Reservoir and Miller's Lake in June and a smaller increase in East in August. Aphanizomenon on the whole was second in abundance, but was later in starting in spring. Coelosphaerium and microcystis were also prominent types. Oscillatoria was not found at any other time except in the May collections and then was in surprising numbers in fact several times as abundant as Anabaena at the same time. The numbers in both lakes happened to be of about the same size as those of the diatom Synedra found in West Reservoir this same month.

Cyanophyceæ thrive best in warm weather, as found in all investigations, and here indicated, for the June water temperature, at the day collected, was 27° C. at the surface. Whipple (1927) says that usually August would be the month for the maximum, or even September. And in his graph for Lake Cochituate he shows it even for October, which is due he notes to the great abundance of Aphanizomenon in October, a genus said to be more tolerant to cold. In this work Aphanizomenon has its maximum at the same time as other blue-greens. Lack of a continued maximum or even a greater flare-up to cause more pronounced water bloom, in July and August, (as already explained) was due to some brief periods of cooler weather, so that the surface water temperature at time of the July collection was 24° C. and of the August collection 23° C., and that of the September date dropped to 18° C. It seems as if these findings will show, if anything, that as sometimes claimed, the increases in Cyanophyceæ come quickly after onset of hot weather, and decrease as quickly after onset of cool weather.

The diatoms had their maximum abundance in the May collection, but this outstanding position was due largely to the great flare-up of Asterionella at this time. Melosira and Synedra, the other commonest diatoms, and also Fragilaria had about an equal representation in April and May, at surface water temperatures of 11° C. and 18° C., respectively. There was a great decrease in months subsequent, except that Melosira had less decrease, and was unusual among diatoms present in having again a great late summer increase, in September and October, chiefly in West Reservoir. But slight increases were noted also in Synedra and Asterionella, though that is scarcely consistent enough to be significant. Fragilaria, the least common of the four diatom genera, did not have any prominent increase, but was found in variable way in the lakes in April, May and June, with none whatever noted after July.

The productivity of Asterionella at the time of its maximum in May (collection on May 25) was the outstanding maximum of all planktonts in the lakes. The highest averages (tables 9 and 10), show for Miller's Lake 359,000 and for East Reservoir 323,109 individuals. But the maximum numbers encountered at any one station was 547,600 at E 4 at 1–2 M., followed by 521,200 at E 7, 1–2 M. In these and several other cases of higher than average numbers, they occurred at 1–2 M. depth rather than at surface or deeper, though this was not the case when smaller numbers were involved, nor for other organisms.

There was a distinct spring maximum, as frequently noticed for diatoms. Lack of collections earlier than April 20, made it impossible to say when the spring increase started. There is also here evidence for an autumn flare-up, as is often described for diatoms, but it began in late summer and was not nearly so great as the spring maximum.

Green algæ coming within the range of those taken by the plankton net were very few in kind and abundance. Only Pediastrum was found in fair numbers in most collections, and is in fact notable for its uniformity throughout the time of collections. There was a slight decrease in August, but again a compensating increase in September despite the drop of water temperature.

Dinobryon, a peculiar colonial Protozoan had its maximum in May. None were present in April, and small numbers in June and July, decreasing thereafter, with none present in October.

Ceratium a common dinoflagellate Protozoan, had its greatest abundance in June and July, with the next principal appearance in September. There was not so great a fluctuation nor so great a maximum in this genus as in Dinobryon. Fewest were present in October.

Condonella, already referred to, was prominent only in April, when it had a decided maximum, but this flare-up was only in East Reservoir, for at the same time in West Reservoir it was taken at only one station. There was a decrease in May, but rather uniform small numbers in all collections, with another increase in fall.

The rotifers of the genera Polyarthra and Anuraea, (the latter now named Keratella) were prominent planktonts in these lakes, with Synchaeta next in number, and Asplanchna occurred in somewhat smaller numbers and in fewer collections. Of other rotifers, only Anapus, (now named Chromogaster), was anything but rare, and it occurred in considerable numbers only in July.

Polyarthra and Anuraea were surprisingly similar in their general distribution and numbers throughout, with only very minor fluctuations between them. The greatest abundance of both was in May but with nearly as large a number in April. There was no marked monthly change thereafter. Synchaeta was commonest in August, September and October, and least in May and June, but no great variation was presented. Asplanchna, never very common, occurred in largest numbers in May, with a fair number in October. The distribution was peculiar because there were none whatever in September, and practically none in June and July, but a few in August.

Cyclops was the only Copepod present. Nauplius larvæ were also recorded, and both of these relatively larger-sized organisms were fairly prominent, though never abundant. Nauplius was encountered more than Cyclops, and both were in larger numbers in April than later, and both presented a monthly distribution with small fluctuations back and forth.

The Cladocera were not as common as one might expect. Daphnia, (of at least two species) was the largest common Cladoceran, and it occurred in only a fraction of the number of Cyclops. Daphnia was chiefly confined to the collections of April, May and June. The smaller water flea Bosmina was more common than Daphnia, with its maximum also in April, May and June.

On the whole Entomostraca may not be expected to reach such great maxima, according to Marsh (1903), who stated that in shallow lakes plant maxima are always outstanding, while Entomostraca and other zooplankton attain rather small numbers, but that in deeper lakes the zooplankton would attain much larger maxima than in shallow waters.

Summary.

In summarizing these findings the following points might be briefly mentioned. The blue-green algæ in number of kinds and relative abundance are about as prominent as expected in such lake waters, though with the greatest maxima probably not realized in the summer season in which the work was done. The green algæ however were not so well represented. The diatoms were also in kind and abundance well developed and prominent, with the usual dominant ones in the lead here. Among other unicellulars, the Protozoa Ceratium and Dinobryon were prominent, as they often are in lake fauna, and in addition equally prominent was Codonella. Rotifers were found in good numbers and all the types found were common lake planktonts. Possibly the Entomostraca seem somewhat deficient. This is due largely to the surprising dearth of Ostracoda. Cyclops, and a few kinds of Cladocera were fairly prominent and numerous.

The seasonal variations or distribution of the planktonts, which was one of the main parts of this work, shows quite a normal distribution, with flare-up of main or dominant groups at times that show only minor variations from what is usual in such shallow bodies of water.

It is, of course, realized that there may be great variations in plankton distribution from year to year in the same body of water, as was for instance stressed by Birge (1896), but then again Marsh (1903) pointed out that in shallow waters where plants are predominant and furnish the outstanding maxima, there is less variation than in deeper lakes. There is not likely to be a striking variation in these lakes from year to year, at least not in the kinds of plankton, nor even in the general trend of the flare-up and maxima of the several kinds and general time in which there occur, for all the observations made on some samples of plankton of other years, showed exactly the same plankton genera, and as far as data was

available, also showed the same trend in their seasonal development. Only the subnormal late July and August temperatures decreased the size of the potential phytoplankton maxima, as already explained.

This paper records the main plankton types of these lakes, and their distribution in various ways, thus giving some data of the plankton biology that may serve as a beginning of a systematic plankton investigation of these lakes and reservoirs.

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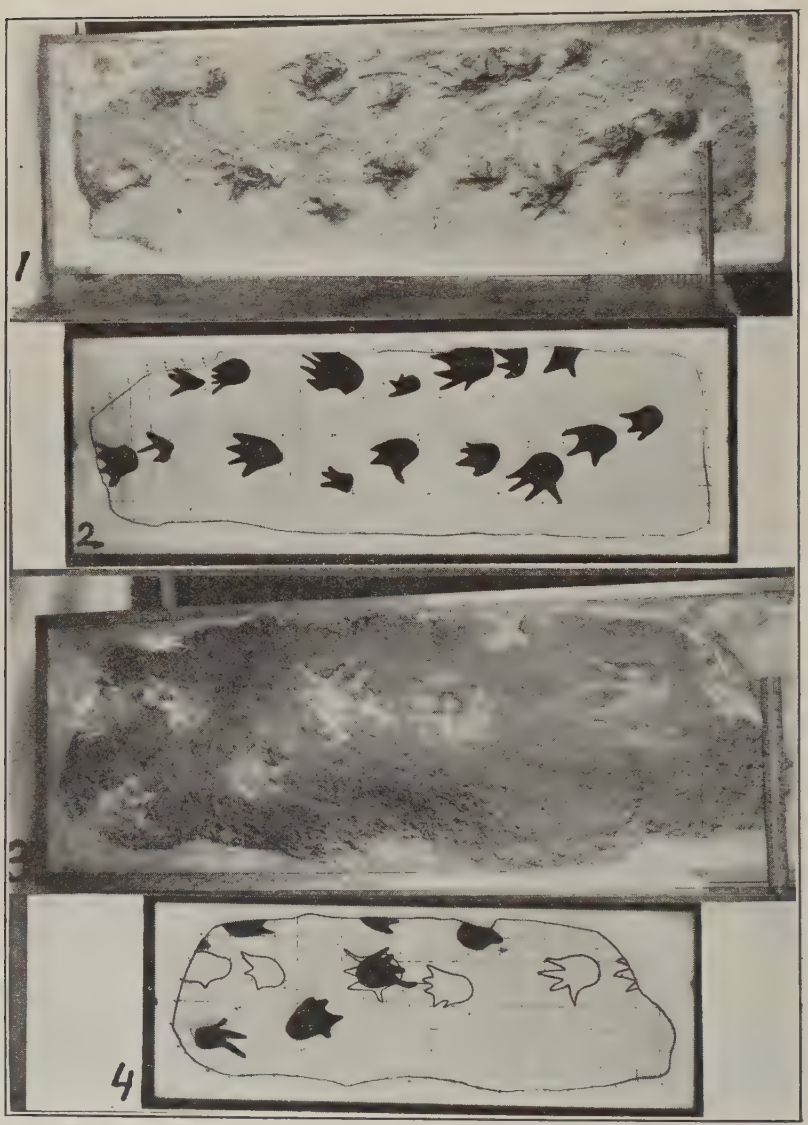
FOSSIL FOOTPRINTS FROM THE PENNSYLVANIAN OF OHIO.

ROBERT H. MITCHELL,
Muskingum College.

At Senecaville, Guernsey County, Ohio, in the Cleveland Mine of the Cambridge Colleries, there is a remarkable number of fossil footprints, all apparently made by the same type of animal, but unfortunately they are poorly preserved. The mud in which the animal walked must have been rather oozy, for it seems to have partly filled the tracks so that the impression of the foot is not clear. These prints are in the shale above the Upper Freeport or number 7 Coal, of the Conemaugh Formation of the Pennsylvanian System. At a number of places in the roof of the mine the footprints are abundant and being fillings of the impressions stand out in relief, the original impressions having fallen from the roof were removed from the mine.

In a small area of 15 feet by 10 feet 30 prints were counted. At another place 100 prints were counted in a space 15 feet square. In still another place two sets of tracks were found, each set showing 80 prints. In one entry 3 sets of tracks were found which seem to have been made by 3 animals coming from different directions and meeting, then proceeding side by side. Each set contains 24 prints of a hind foot and 24 prints of a front foot making a total of 48 prints made by the left feet of the animal and a like number made by the right feet. As there are 3 sets of such tracks the total number of tracks counted in a space 25 feet by 15 feet was 288. At various places in the mine other groups of prints were found, 100 prints were counted at one place in an area of 15 feet by 10 feet, 160 prints were counted at another place in a space 25 feet by 15 feet, and at still another place in a space 15 feet square 108 prints were counted. Numerous other prints were observed which are not mentioned here. Other observers report large numbers of tracks counted at places in the mine where the shale containing them has since fallen. In most cases these tracks extend diagonally across the entry or almost parallel with it. In many cases not a track in the series is missing.


1
2
3
4

The tracks are found in two rows corresponding to the right and left feet of the animal. These rows are separated by a distance of about 11 inches. In each row two types of tracks are found which alternate and must represent the front and hind feet of an animal which possessed a plantigrade foot.

The writer knows of no other place in Ohio where tracks are so abundant. In the same shale in which the tracks are found, fossil plants, especially Lepidodendra and Calamites which are preserved as carbon films, are rather numerous in about the same areas as those in which the prints are found. It is quite possible that the amount of vegetable matter in the area has some bearing on the large number of tracks. Possibly the animals congregated here at a feeding ground to eat the apparently abundant vegetation.

Perhaps the best preserved prints from this mine are now in the collection of Muskingum College, New Concord, Ohio. These are two slabs of shale, one 5 feet 5 inches by one foot 8 inches and contains 16 prints or parts of prints. Since the tracks on this slab are fillings of impressions they stand out in relief; however they are not well preserved and are typical of those found in the roof of this mine. Figure 1 shows a photograph of this slab. It will be noted by reference to Figure 2, which is a scale drawing of this slab, that some of the larger prints show 4 toes, the outer one of which is turned outward and back, hook-like. The smaller prints are less well preserved but probably represent the other type of foot.

Figure 3 shows the second slab of the collection, which is one foot 2 inches by 3 feet 9 inches and contains 13 prints or parts of prints. The prints are impressions of the animal's foot and are better preserved than the fillings of the impressions. This slab was found on the mine dump and is the type of impression which falls from the roof of the mine leaving the fillings of the impressions standing out in relief. Note that one type of foot has 4 toes with the outer hook-like digit while the other type has 5 shorter more slender toes.

Figure 4 is a scale drawing of this slab and shows two sets of prints in opposite directions. Those drawn in solid black apparently made by an animal going in the opposite direction to that which made the tracks drawn in outline.

As has already been noted there are two types of tracks, one type has 4 rather long, broad toes, the outer one of which is pointed outward and back, hook-like, while the other type of

track has 5 toes which are shorter and more slender. In both types of track the inner edge of the track is deeper than the outer edge, having a depth of about ½ inch. The length of the 4-toed type is about 5½ inches, the toe spread 4½ inches, the width of the sole 2½ inches, length of the sole 3 inches. The inner digit is about 1¾ inches long and points slightly outward. The next digit is 2¼ inches long and is also pointed outward. These digits are about 1¼ inches apart at their ends, and are directed almost straight ahead. The next is about 2½ inches long and points outward, having its end about 2¼ inches from the end of its neighbor. The outer digit, which is about 2 inches long, curves outward and back, hook-like, and is the thickest of the digits. Its end is about 3¼ inches from that of the one just next to it.

The other type of track shows the 5-toed foot which is about 5 inches long. The toe spread is 4¼ inches, width of sole 2½ inches and length of sole 3¼ inches. The digits are all short, about 1¼ inches long, and more slender than those of the previously described type. The outermost digit is one inch from the base of its neighbor and is deeper on the inner side.

The stride of the animal varies from 15 inches in some cases to 17¾ inches in others. The width of the trackway in all cases is about 11 inches. This gives us a ratio of the width of trackway to length of stride of 1 to 1.7.

The description of the tracks on the two slabs pictured here correspond quite well to Ancylopus ortoni, Carman (1), in all ways except size. The general shape of the prints are the same but the stride and the dimensions of the feet are somewhat smaller. It is quite evident, therefore, that they are those of Ancylopus ortoni, Carman. This is, then, a new location for this animal geologically as well as geographically for the type horizon is the shale above the Middle Kittaning Coal, of the Allegheny Formation of the Pennsylvanian System, which is about 100 feet lower than the shale in which the specimens here described were found. All the tracks in the roof of the mine appear to have been made by the same type of animal although they are usually so poorly preserved that one can not be certain. The striking thing about this locality is the great abundance of tracks all apparently made by the same type of animal.

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ADDITIONAL MALLOPHAGA FROM OHIO BIRDS.*

ROBERT M. GEIST,
Department of Zoology, Capital University.

In a paper published in 1928 Peters listed 94 species of Mallophaga from 114 species of birds taken in Ohio.

The following list includes 45 additional species of Mallophaga from 91 species of Ohio birds. A number of these host records are new as there are, to my knowledge, no published records of any parasite species ever having been taken from some of the host species. In some other instances the record of a parasite species on a host form is new for that host.

Most of the collecting of both birds and parasites was done by the writer during the last four years. Many specimens, however, were collected by Charles F. Walker and Milton B. Trautman whose assistance I gratefully acknowledge.

All the specimens from which this list was compiled are located in the University collection and in my own personal collection.

In this list Harrison's sequence is followed where possible.

LIST OF MALLOPHAGA FROM OHIO BIRDS.

Order MALLOPHAGA Nitzsch.

Suborder AMBLYCERA Kellogg.

Family *Menoponidæ* Mjoberg.

Menopon Nitzsch.

M. maestum Kellogg and Chapman. Towhee, *Pipilo erythrophthalmus erythrophthalmus* (Linn.), Columbus.

Colpocephalum Nitzsch.

C. haliaeti Denny. Osprey, *Pandion haliaetus carolinensis* (Gmel.), Columbus.

C. spinulosum Piaget. Baird sandpiper, *Pisobia bairdi* (Coues), Buckeye Lake.

C. unciferum Kellogg. White pelican, *Pelecanus erythrorhynchus* Gmel. Buckeye Lake.

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*Contribution Number 2, new series, from the Department of Zoology, Capital University, Columbus, Ohio.

Cuculiphilus Uchida

C. fasciatus (Scopoli). Black billed cuckoo, *Coccyzus erythrophthalmus* (Wilson), Buckeye Lake.

Menacanthus Neumann.

M. chrysophaeum (Kellogg). Goldfinch, *Astragalinus tristis tristis* (Linn), Urbana; field sparrow, *Spizella pusilla pusilla* (Wilson), Sugar Grove; song sparrow, *Melospiza melodia melodia* (Wilson), Columbus; meadow lark, *Sturnella magna magna* (Linn.), Columbus; ovenbird, *Seiurus aurocapillus* (Linn.), Buckeye Lake; Connecticut warbler, *Oporornis agilis* (Wilson), Buckeye Lake; northern yellow-throat, *Geothlypis trichas trichas* (Linn.), Columbus.

M. persignatus (Kellogg). Robin, *Planesticus migratorius migratorius* (Linn.), Columbus; bronzed grackle, *Quiscalus quiscula aeneus* Ridgway, Columbus.

Myrsidea Waterston.

M. dissimilis (Kellogg). Tree swallow, *Iridoprocne bicolor* (Vieill), Buckeye Lake; barn swallow, *Hirundo erythrogaster* Boddaert., Columbus.

M. incerta (Kellogg). Olive backed thrush, *Hylocichla ustulata swainsoni* (Tschudi), Columbus; bay breasted warbler, *Dendroica castanea* (Wilson), Columbus; blackburnian warbler, *Dendroica fusca* (Muller), Columbus; hermit thrush, *Hylocichla guttata pallasi* (Cabanis), Columbus.

Machaerilaemus Harrison.

M. laticorpus (Carriker). Bobolink, *Dolichonyx oryzivorus* (Linn.), Columbus; indigo bunting, *Passerina cyanea* (Linn.), Columbus; cowbird, *Molothrus ater ater* (Boddaert), Buckeye Lake.

Actornithophilus Ferris.

A. aegialitidis (Durrant). Black bellied plover, *Squatarola squatarola cynosurae* Thayer and Bangs, Buckeye Lake; ruddy turnstone, *Arenaria interpres morinella* (Linn.), Buckeye Lake; sanderling, *Crocethia alba* (Pallas), Buckeye Lake.

A. tigrus (Kellogg and Mann). Ruddy turnstone, *Arenaria interpres morinella* (Linn.), Buckeye Lake.

A. timidus (Kellogg). Sanderling, *Crocethia alba* (Pallas), Buckeye Lake.

Ferrisia Uchida.

F. laticeps (Kellogg). Snowy Egret, *Egretta candidissima candidissima* (Gmel.), Buckeye Lake.

Trinoton Nitzsch.

T. querquedulae (Linn.). Blue winged teal, *Querquedulæ discors* (Linn.), Buckeye Lake; green winged teal, *Nettion carolinense* (Gmel.), Buckeye Lake.

Pseudomenopon Mjoberg.

P. pacificum (Kellogg). Yellow rail, *Coturnicops noveboracensis* (Gmel.), Westerville; Virginia rail, *Rallus virginianus* Linn., Columbus.

P. tridens (Nitzsch). Coot, *Fulica americana* Gmelin., Buckeye Lake.

Family *Ricinidæ* Neumann.

Ricinus DeGeer.

R. angulatus (Kellogg). Vesper sparrow, *Pooecetes gramineus gramineus* (Gmel.), Columbus; Lapland longspur, *Calcarius lapponicus lapponicus* (Linn.), Columbus; Savannah sparrow, *Passerculus sandwichensis savanna* (Wilson), Columbus; blue gray gnatcatcher, *Polioptila caerulea caerulea* (Linn.), Columbus; magnolia warbler, *Dendroica magnolia* (Wilson), Sugar Grove; snow bunting, *Plectrophenax nivalis nivalis* (Linn.), Fredericktown.

R. pallens (Kellogg). Prairie warbler, *Dendroica discolor* (Vieillot), Sugar Grove; blackburnian warbler, *Dendroica fusca* (Muller), Columbus; palm warbler, *Dendroica palmarum palmarum* (Gmel.), Columbus; golden crowned kinglet, *Regulus satrapa satrapa* Lichtenstein, Buckeye Lake; Bachman sparrow, *Peucaea aestivalis bachmani* (Aud.), Sugar Grove; tree sparrow, *Spizella monticola monticola* (Gmel.), Columbus; scarlet tanager, *Piranga erythromelas* Vieillott, Sugar Grove; northern yellowthroat, *Geothlypis trichas trichas* (Linn.), Columbus.

Suborder Ischnocera Kellogg.

Family *Philopteridæ* Burmeister.

Goniodes Nitzsch.

G. mammillatus Rudow. Ring necked pheasant, *Phasianus colchicus torquatus* Gmelin, Wellington.

Philopterus Nitzsch.

P. conicus (Denny). Black bellied plover, *Squatarola squatarola cynosurae* Thayer and Bangs, Buckeye Lake; ruddy turnstone, *Arenaria interpres morinella* (Linn.), Buckeye Lake; sanderling, *Crocethia alba* (Pallas), Buckeye Lake.

P. evagens (Kellogg) Red headed woodpecker, *Melanerpes erythrocephalus* (Linn.), Columbus.

P. excisus (Nitzsch). Barn swallow, *Hirundo erythrogaster* Boddaert, Columbus; tree swallow, *Iridoprocne bicolor* (Vieillott), Buckeye Lake.

P. fuscoventralis (Osborn). Olive sided flycatcher, *Nuttallornis borealis* (Swainson), Buckeye Lake.

P. fusiformis (Denny). Least sandpiper, *Pisobia minutilla* (Vieillot), Bono.

P. incisus (Kellogg). Golden crowned kinglet, *Regulus satrapa satrapa* Lichtenstein, Buckeye Lake; tree swallow, *Iridoprocne bicolor* (Vieillot), Buckeye Lake.

P. melanocephalus (Burm.). Parasitic jaeger, *Stercorarius parasiticus* (Linn.), Buckeye Lake.

P. subflavescens (Geoff.). White eyed vireo, *Vireo griseus griseus* (Boddaert), Buckeye Lake; blue jay, *Cyanocitta cristata cristata* (Linn.), Columbus; mockingbird, *Mimus polyglottos polyglottos* (Linn.), Columbus; red winged blackbird, *Agelaius phoeniceus phoeniceus* (Linn.), Columbus; migrant shrike, *Lanius ludovicianus migrans* W. Palmer, Columbus; red start, *Setophaga ruticilla* (Linn.), Sugar Grove; red eyed vireo, *Vireosylvia olivacea* (Linn.), Sugar Grove; purple finch, *Carpodacus purpureus purpureus* (Gmel.), Buckeye Lake; snow bunting, *Plectrophenax nivalis nivalis* (Linn.), Buckeye Lake; hermit thrush, *Hylocichla guttata pallasi* (Cabanis), Buckeye Lake; field sparrow, *Spizella pusilla pusilla* (Wilson), Sugar Grove; slate colored junco, *Junco hyemalis hyemalis* (Linn.), Sugar Grove; indigo bunting, *Passerina cyanea* (Linn.), Columbus; horned lark, *Otocoris alpestris alpestris* (Linn.), Columbus; white crowned sparrow, *Zonotrichia leucophrys leucophrys* (J. R. Foster), Columbus; tree sparrow, *Spizella monticola monticola* (Gmel.), Buckeye Lake; olive backed thrush, *Hylocichla ustulata swainsoni* (Tschudi), Columbus; Philadelphia vireo, *Vireosylvia philadelphica* Cassin, Bono; Kentucky warbler, *Oporornis formosus* (Wilson), Sugar Grove.

Anatoecus Cummings.

A. dentatus (Scopoli). Blue winged teal, *Querquedula discors* (Linn.), Buckeye Lake; gadwall, *Chaulelasmus streperus* (Linn.), Buckeye Lake; wood duck, *Aix sponsa* (Linn.), Buckeye Lake; bufflehead, *Charitonetta albeola* (Linn.), Buckeye Lake.

Degeeriella Neumann.

D. complexiva (Kellogg and Chapman). White rumped sandpiper, *Pisobia fuscicollis* (Vieillot), Buckeye Lake; western sandpiper, *Ereunetes mauri* Cabanis, Buckeye Lake; red backed sandpiper, *Pelidna alpina sakhalina* (Vieillot), Buckeye Lake.

D. fusca (Nitzsch). Sharp shinned hawk, *Accipter velox* (Wilson), Buckeye Lake; red tailed hawk, *Buteo borealis borealis* (Gmel.), Columbus; marsh hawk, *Circus hudsonius* (Linn.), Attica.

D. illustris (Kellogg). Bronzed grackle, *Quiscalus quiscula aeneus* Ridgway, Lancaster; bobolink, *Dolichonyx oryzivorus* (Linn.), Columbus.

D. infecta (Kellogg and Kuwana). Red phalarope, *Phalaropus fulicarius* (Linn.), Buckeye Lake.

D. longa (Kellogg). Tree swallow, *Iridoprocne bicolor* (Vieillot), Buckeye Lake; purple martin, *Progne subis subis* (Linn.), Columbus; rough winged swallow, *Stelgidopteryx serripennis* (Aud.), Buckeye Lake.

D. picturata (Osborn). Meadow lark, *Sturnella magna magna* (Linn.), Columbus.

D. simplex (Kellogg.) Mockingbird, *Mimus polyglottos polyglottos* (Linn.), Buckeye Lake.

D. vulgata (Kellogg). Slate colored junco, *Junco hyemalis hyemalis* (Linn.), Lancaster; white throated sparrow, *Zonotrichia albicollis* (Gmel.), Columbus; Bachman sparrow, *Peucaea aestivalis bachmani* (Aud.), Sugar Grove; cedar waxwing, *Bombycilla cedrorum* Vieillot, Sugar Grove; blue winged warbler, *Vermivora pinus* (Linn.), Sugar Grove; swamp sparrow, *Melospiza georgiana* (Latham), Columbus; English sparrow, *Passer domesticus domesticus* (Linn.), Attica; Bewick's wren, *Thryomanes bewicki bewicki* (Aud.), Columbus.

Rallicola Johnston & Harrison.

R. advena (Kellogg). Coot, *Fulica americana* Gmelin, Buckeye Lake.

R. bisetosa (Piaget). Yellow rail, *Coturnicops noveboracensis* (Gmel.), Westerville.

R. californica (Kellogg and Chapman). Virginia rail, *Rallus virginianus* Linn., Columbus.

Esthiopterum Harrison.

E. botauri (Osborn). Least bittern, *Ixobrychus exilis* (Gmel.), Buckeye Lake.

E. comstocki (Kellogg and Chapman). Yellow rail, *Coturnicops noveboracensis* (Gmel.), Westerville.

E. columbae (Linn.). Mourning dove, *Zenaidura macroura carolinensis* (Linn.), Columbus.

E. crassicorne (Scopoli). Pintail, *Dafila acuta tzitzihoa* (Vieillot), Buckeye Lake; bufflehead, *Charitonetta albeola* (Linn.), Buckeye Lake.

E. forficulatum (Nitzsch). White pelican, *Pelecanus erythrorhynchos* (Gmel.), Buckeye Lake.

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OBITUARIES

JAMES STEWART HINE.*

Professor James Stewart Hine, Curator of the Division of Natural History of the Ohio State Archaeological and Historical Museum, and a recent President of this Academy, died December 22, 1930. His death was due to an acute heart attack and occurred in his home while he, his children and the neighbor children were making preparations for Christmas. Professor Hine had always enjoyed robust health. His taking away was without warning.

Professor Hine was born at Wauseon, Ohio, June 13, 1866, was raised on a farm and worked his way through Ohio State University, where he received the B. S. degree in 1893. From this time to his death his activities were centered on the University Campus, first on the faculty of Ohio State University, and in his later years at the Archaeological Museum. He was Assistant in Horticulture, 1894, and from 1895 to 1899 he was Assistant in Entomology, from 1899 to 1902, Assistant Professor of Zoology and Entomology, and from 1902 to 1925, Associate Professor of Entomology. In 1925 the Ohio State Archaeological Museum decided to develop a Division of Ohio Natural History which could co-operate with the state high schools and Professor Hine, because of his wide knowledge of the state fauna, was asked to organize the division. During 1925–1927 he devoted half his time to teaching and half to the organization of the Division of Natural History. From 1927 till his death, 1930, he devoted full time to the latter position.

Professor Hine was essentially a field and museum man. He was familiar with every region of Ohio and had made many trips farther afield, to the Gulf Coast, 1903; Central America, 1905; California, Arizona and Mexico, 1907; two trips to Alaska, 1917 and 1919, and to Florida and Cuba, 1923. He spent the year 1922–23 studying in the Zoological Museum of the University of Michigan and August of 1925 in the British

*Summary of remarks presented at the Oxford meeting of the Ohio Academy of Sciences.

JAMES STEWART HINE

(Courtesy of the Ohio Archaeological Society.)

Museum, besides other shorter trips at times to various American collections.

Besides his interest in insects, Professor Hine was a charter member of the O. S. U. Biological Club, he organized the first Wheaton Club and was President of the second Wheaton Club. He had been President of the Ohio Beekeepers Association and recently (1929) President of the Ohio Academy of Science. In the following articles will be found further details of his scientific work:

McAtee, Waldo. "James Stewart Hine." Auk, Vol. 48, No. 2, pp. 323–325. 1931.

Kennedy, C. H. "Obituary" (James Stewart Hine). Ent. News, Vol. 42, pp. 177–180. 1931.

Galbreath, C. B. "James S. Hine." Museum Echoes (Ohio Arch. Mus.). Vol. 4, No. I, p. 2. Portrait. 1931.

Cockins, E. D. "Publications of the teaching staff." O. S. U. Bull., Vol. 26 (1921), pp. 63–68; Vol. 29 (1925), p. 22.

C. H. Kennedy.

CHARLES DURY.

The death of Charles Dury on July 20, 1931, in his eighty-fourth year, after a few days illness, has removed from the ranks of American entomology one of its oldest workers. His interests were, however, broader than the branch in which he specialized and by which he is best known among entomologists. He belonged to that old-time group of naturalists—so few in these days of specialization—whose studies embraced the whole field of natural history. In this broader field, his chief interest lay in ornithology; many published papers attest to his careful observations of birds.

Charles Dury was born in Cincinnati, Ohio, November 14, 1847, the son of Francis W. Dury and Louisa M. Gibson. In 1862, Francis Dury settled in the suburb of Avondale (now a part of Cincinnati) and in the immediate vicinity of the original Dury homestead, Charles Dury passed the remainder of his long and active life.

Mr. Dury early acquired a taste for natural history, and in those days, his immediate surroundings offered ample opportunity for the development of his studies. His first active work was in ornithology. To his field observations he added a study of taxidermy, and about 1867, opened a shop for that work, which he carried on some forty years. Many beautifully mounted birds and mammals show his skill in taxidermy, for which he received a number of competitive awards. Early in life he attended the Miami Medical College, but did not carry his studies to completion.

Entomology later increasingly claimed his time and attention, and his collection of insects, particularly of Coleoptera, brought together from all parts of the world, is for North American forms, one of the finest and most complete in this country. This collection is left to his son, Ralph Dury, now Director of the Cincinnati Society of Natural History.

Although he published a number of papers on North American Coleoptera and described many new species, these but poorly represent the extent of his knowledge and the wealth of his observations in his chosen field. An authority on the Coleoptera, it is the regret of his friends and fellow students

CHARLES DURY

(Courtesy of Proc. Junior Society of Natural Sciences.)

that he could not be induced to publish his observations more freely.

An indefatigable collector and observer of nature, Mr. Dury acquired a fund of first-hand knowledge. The benefit of his experience he was always ready to give to others, and through advice and encouragement started many young students along the path to success. The writer of this article will never forget the sympathetic aid given her at the beginning of her entomological studies by this veteran entomologist, nor the opportunity for the exchange of ideas throughout many years.

Through correspondence, association in the field or study in museums, he was well known to the older taxonomic workers in most groups of insects. Entomologists throughout the country, and especially Ohio entomologists, will mourn his passing. Probably his closest entomological friend and his companion of many field trips was Professor J. S. Hine. Both possessed the same untiring energy and enthusiasm that mark the successful field worker.

The versatility of his interests and the long period of his scientific activity brought him in contact with many scientists of an earlier generation and gained for him the friendship of such men as Alfred Russell Wallace, E. D. Cope, Spencer F. Baird, George Horn, John L. LeConte, Robert Ridgway, and Elliot Coues.

Mr. Dury held membership in many scientific societies. The records of the Ohio Academy of Science show that he was a member from 1895 to 1919, Vice-President in 1896, President in 1907, and Trustee of the Research Fund 1907–08. He was a charter and life member of the Cincinnati Society of Natural History, its curator of ornithology and entomology, its Secretary in 1912 and its President from 1914 until his death. The oldest member and a life member of the Cuvier Press Club, he was the custodian of their collection, a generous donor to the collection, and the preparator of nearly all of the specimens. At one time he served on the advisory board of the Audubon Society. He was a former member of the American Association for the Advancement of Science, and at the time of his death, a member of the Brooklyn Entomological Society.

His straightforwardness and integrity of character won for him the respect of all; he was a gracious teacher and a faithful friend.

Surviving him are his widow, Mrs. Pearl Welch Dury; two sons, Ralph and Arthur; a daughter, Mrs. Louise Hippert, and two grandsons. To these, his friends and fellow scientists offer their sympathy in the loss they have sustained.

ANNETTE F. BRAUN.

EDITORIAL NOTE.

In view of the intimate association of Charles Dury and Professor J. S. Hine, it seems fitting that we should present together sketches of their life work in Ohio. Both were born, lived, and worked in Ohio. Both were exceptionally successful as field workers in biology, interested in all phases of life and familiar with native plants and animals, but especially birds and insects. Both contributed extensively to the literature of the Ohio fauna, their papers as listed in the Bibliography of the Ohio Zoology, numbering fifty-one for Dury and sixty-three for Hine. Both served as President of the Ohio Academy of Science and Professor Hine was, for many years, the business manager of the Ohio Naturalist and Ohio Journal of Science.

H. O.

INDEX TO VOLUME XXXI.

Absorption of Water by Root System Plants, 273.
Abstracts, 260, 418.
Address of the President, 243.
Agallia, The Genus, External Characters Used to Distinguish the Species Injuring Economic Crops, 377.
Ahlstrom and Tiffany, article by, 455.
Alexander, W. H., article by, 193.
Algæ of Southern Florida, Freshwater, 271.
Algæ, Plankton, 455.
Alimentary Canal of Asaphes mimnonius Hbst., 386.
Alimentary Canal of Meracantha contracta Beauv. (Tenebrionidæ), 143.
Alimentary Canal of Sphaeroderus nitidicollis Chev. var. Schaumi Chd., 406.
Ancient Life of the Arctic, 243.
Anticipation of Correct Responses as a Source of Error in Learning Serial Responses, 419.
Arctic, Ancient Life of, 243.
Argulidæ, 453.

Bainbridge Limestone, Remarkable Fossiliferous Lens in, 278.
Baldwin, S. Prentiss, articles by, 172, 260, 269.
Bangham, Ralph V., article by, 263.
Basal Metabolism of College Students, 288.
Bean, Lonzo G., article by, 290.
Berry, Willard, article by, 281.
Bigham, John T., article by, 386.
Biological Evolution, Present Tendencies in the Philosophy of, 129.
"Bird Sanctuary" Suggestions, 172.
Bisporangiate Inflorescences in Pseudotsuga, 416.
Blarina brevicauda (Say) Habits of the Short Tailed Shrew, 97.
Blood Pressure of an Opossum, 294.
Book Reviews, 176, 180, 192.
Brassfield Limestone in Southeastern Ohio, Horizon of the, 275.
Braun, Annette, article by, 512.
Bucher, Walter H., article by, 282.
Burtt, Harold E., article by, 418.

Camp, W. H., article by, 157.
Cephalopods of America, Europe and Asia, Earliest Known, 280.
Cercaria gorgonocephala Ward, Observations on, 115.
Check-list as an Instrument to Determine Personality Changes in Preschool Children, 425.
Chen, T. T., article by, 262.
Chroococcus limneticus, 455.
Collection of "Progress" Indices for Ohio Counties, 424.
Comments on the Interrelations of Intelligence Test Score, Stated Intention of Going to College and Occupational Choice of High School Seniors, 426.
Comparison of the High Relief Finger Maze and an Improved Form of the Stylus Maze, 419.
Comparison of the Maine and Connecticut Shorelines, 283.
Copepods, Parasitic, 453.
Coregonus clupeaformis, Embryology of the Whitefish, 268.
Correlation Between Dry Weather and the Storage of Organic Reserves in Alfalfa Roots, 272.
Crucigenia apiculata var. eriensis, 463.
Crustacean, A New, 127.
Cummins, James W., article by, 275.

Davidson, Ralph H., article by, 377.
Davis, B. M., article by, 286.
DeLong, Dwight M., article by, 177, 377.
Dental Hygiene, Status of, 290.
Determinate Evolution. IV, Studies in, 1.
Determination of the Dielectric Constants and Densities of Brom-Benzene-Hexane Solutions, and the Determination of the Electric Moment of the Brom-Benzene Molecule, 298.
Devonian Corals of Ohio, 275.
Dictyosphaerium planctonicum, 458.
Dietary Habits of Barn Owls in Ohio, 263.
Diurnal Variations, Fish Ponds at Fairport, Iowa, 120.
Dolomite in an Ohio Cave, Recent Formation of, 276.
Drainage Changes in the Vicinity of Loudonville, Ohio, 368.
Drainage Systems and the Dynamic Cycle, The Development of, 309.
Dudycha, George J., articles by, 107, 129.
Dunham, W. E., article by, 181.

Dunn, Paul H., article by, 278, 279.
Dury, Charles, Obituary, 512.

Ecology of Some Grasshoppers of the Genus Melanoplus in Southeastern Ohio, 265.
Edgerton, Harold A., article by, 426.
Editorial Note, 514.
Effect of Emotional Stimuli on the Activity Level of the White Rat, 419.
Effect of Hypnosis on Long Delayed Recall, 425.
Effect of Rhythm and Reverie on the Machine Worker, 425.
Epibranchial Ganglion of the Glosso-Pharyngeal Nerve in Amblystoma jeffersonianum, 335.
Ergasilidæ, 454.
Erosion Surfaces in Eastern Ohio, 277.
Evolution, LeConte's Epitome of, 107.
Evolutionary Movements, Characteristic Examples of Accumulative Progressive; Studies in Determinate Evolution, V, 346.
Evolution of the Sciences, An Optimistic View of the, 255.
Evolution, Present Tendencies in the Philosophy of Biological, 129.
Evolution, IV, Studies in Determinate, 1.
Experiment on the Relative Effectiveness of the Lecture-quiz and the Recitation Methods of Class Instruction in Elementary Psychology, 418.

Field Trip, Announcement of Plans for, 278.
Findings in the Part and Whole Methods of Learning, 423.
Finley, George W., article by, 270.
Finns in Ohio, 277.
Fish Ponds, Diurnal Variations in the Amount of Dissolved Oxygen, Alkalinity, and Free Ammonia, 120.
Foerste, Aug. F., articles by, 243, 280.
Fossil Footprints, 501.
Footprints, Fossil, 501.
Footprints from the Pennsylvanian, Fossil, 281.
Foraminifera of the Bainbridge, 279.
Franceia tuberculata, 462.
var. irregularis, 463.
Frost, R. B., article by, 284.

Gastric Ulcer, Studies on, 295.
Geist, R. M., article by, 505.
Genus Agallia—External Characters Used to Distinguish the Species Injuring Economic Crops, 377.
Geography of Onion Culture, A Study in the, 17.
Geology of the Vicinity of Ticonderoga, 284.
Glaciation of Northwestern Holmes County, Ohio, 429.
Glock, Waldo S., article by, 309.
Golenkinia maxima, 461.
radiata var. brevispina, 461.
Gomphosphaeria lacustris, 457.
Graham, William A. P., article by, 127.
Grass Balds of the Great Smoky Mountains, 157.
Gratz Division of the Cynthiana Series of Central Kentucky, 274.
Growdon, C. H., article by, 422.

Hall, C. W., article by, 424.
Hamilton, W. J., Jr., article by, 97.
Hamlin, H. E., article by, 294.
Health Habits of University Women, 286.
Hefner, R. A., article by, 265.
Heil, Louis M., article by, 298.
Henderson, Nellie F., article by, 44.
Heronries of Northern Ohio, 270.
Hine, James Stewart, Obituary of, 510.
Histology of the Intestinal Tract of Two Minnows, Notemigonus Chrysoleucas and Notropis atherinoides, 268.
Hive Temperatures for Each Hour of a Day, 181.
Holmes County, Glaciation of, 429.
Hypnales, Ohio, 44.
Hypnosis on Long Delayed Recall, Effect of, 425.
Hypsometric Map versus the Projected Profile Method in Depicting and Determining Erosion Surfaces, 285.
Hypsometric Map versus the Projected Profile Method in Portraying and Determining Erosion Surfaces, 189.

Industrial Adjustments in the Miami Valley, 283.
Iris of Ohio and Bordering Territory, The Native, 29.

Kendall, Robert, article by, 276.
Kendeigh, S. Charles, article by, 261.
Kennedy, C. H., article by, 510.
Kroc, Robert L., article by, 288.
Kostir, W. J., article by, 260.
Kraatz, Walter C., article by, 475.
Kramer, Paul J., article by, 273.

Laboratory Studies of Living Birds, 260.
Lagerhimia citriformis, 461.
citriformis var. paucispina, 462.
longiseta var. major, 462.
wratislawiensis, 462.
Landacre, F. L., article by, 335.
Lane, George H., article by, 165.
Lecture Demonstration and Individual Laboratory Methods of Introducing College Students to First Year Chemistry, 427.

Lehman, Harvey C., article by, 421.
Lernaeidæ, 454.
Lerneaopodidæ, 454.
Limestone Caverns, Origin of, 276.
Limnological Survey of the Hocking River, 267.
Littlefield, E. W., article by, 416.
Lord, Richard C., article by, 276.
Loss in Dry Matter in Sweet Clover Roots from Fall to Spring, 274.
Lowry, Philip Rosemond, Obituary, 191.
Ludwig, William B., article by, 267.
Lumley, Frederick Hillis, article by, 419.

Mallophaga from Ohio Birds, 505.
Marsoniella elegans, 458.
Mathews, A. A. L., article by, 279.
Mathews, C. O., article by, 420.
Mathewson, Stanley B., article by, 425.
McNelly, W. C., article by, 285.
Mental Status of Reformatory Women, 422.
Meracantha contracta Beauv., The Alimentary Canal of, 143.
Merismopedia convoluta, 457.
Micractinium eriense, 460.
pusillum var. longisetum, 460.
Micrantinium pusillum, 460.
Micromoving Pictures of the Circulation in Living Bird Embryos, 260.
Miller, Warren C., articles by, 143, 266.
Mitchell, Robert H., articles by, 281, 501.
Morphology of the Anterior Sympathetic Nervous System of Lumbricus terrestris, 262.
Moseley, E. L., article by, 270.
Mosses, Ohio, 44.

Neiswander, B. E., article by, 289.
Nelson, B. B., article by, 419.
Nesting Success of a Song Sparrow Population in 1930, 261.
Net-Plankton Survey, 475.
New Crustacean of the Family Aglaspidæ from the Upper Mississippi Valley, 127.
Nice, Margaret Morse, article by, 261.
Notropis volucellus wickliffi, 468.
Notropis volucellus wickliffi n. sub. sp., 470.

Obituaries, 510.
Objective Study of Student and Faculty Attitudes Toward Academic Honesty, 420.
Ohio Vascular Plants for 1930, Additions to the Catalog of, 299.
Ohio Mosses, Hypnales, 44.
Ohmann, O. A., article by, 298.
Oligochaete New to America, A New, 264.
Oocystis eremosphaeria, 459.
Orogenic Deformation Continuous or Discontinuous for the Earth as a Whole, 282.
Osborn, Herbert, articles by, 191, 514.
Book Reviews, 180, 192.

Paleobotany in Ohio, Status of, 281.
Paragenetic Relations of Galena-Sphalerite, 278.
Parasites of Buckeye Lake Fish, 263.
Parasitic Copepods, 453.
Parks, Skinning our, 269.
Passalus cornutus, Observations on the Habits of, 266.
Patrick, James R., article by, 419.
Payne, V. F., articles by, 255, 427.
Phototropic Responses of Drosophila hydeii, Report on, 265.
Piersel, W. G., article by, 425.
Plankton Algæ from Lake Erie, 455.
Plant Taxonomy, X, Principles of, 77.
Poisonous Plants Indigenous to Indiana, 270.
Pollen Analysis of Bacon's Swamp at Indianapolis Evidence of Two Dry Climates in Post-Wisconsin Time, 272.
Pollen Analysis of the East McCulloch Peat Bed, 165.
Presidential Address, 243.
Price, John W., article by, 268.
Proceedings, Forty-first Annual Meeting, Ohio Academy of Science, 193.

Rating Scales in Industry, 421.
Regulation of Body Temperature in Birds, 261.
Remmers, H. H., article by, 418.
Reports, 223–238.
Report on a New Diagnostic Technique for Studying Social and Emotional Adjustment, 298.
Respiratory Apparatus of Parajulus impressus Say, 265.
Rhythm and Reverie on the Machine Worker, Effect of, 425.
Roach, Lee Stewart, article by, 267.
Rogers, C. G., articles by, 262, 288.
Ross, C. C., article by, 427.

Scenedesmus bijuga, 464.
Schaefer, Paul Everett, article by, 406.
Schaffner, John H., articles by, 1, 77, 299, 346.
Schmidt, Leon H., article by, 295.
Scientists and Church Membership, 421.
Scioto Marshes of Ohio: A Study in the Geography of Onion Culture, 17.
Scott, T. C., article by, 419.
Sears, Paul B., article by, 272.
Sectioning Chamber, A, 118.
Selbert, Norma, article by, 286.

Selenastrum bibraianum var. gracile, 463.
Sex-Character Education Through Pets, 295.
Sharp, Henry S., article by, 283.
Silicosis of Ohio Industries: A Preliminary Report, 289.
Smith, Ernest Rice, article by, 276.
Spencer, Warren P., article by, 264.
Stalnaker, John M., article by, 425.
Stewart, Grace A., article by, 275.
Stratigraphy of the Central Wasatch Mountains, Pre-Mesozoic, 279.
Stupka, Arthur, article by, 263.
Suggestibility as Influenced by the Form of the Question, 418.
Summer Rainfall of 1930: A Relative Representation, 284.
Surrarrer, Thomas, article by, 268.
Swinnerton, A. C., articles by, 276, 284.

Tanais cavolinii Milne-Edwards, 264.
Tashiro, Shiro, article by, 295.
Temperature Abnormalities in Indiana and Kentucky Highs, 276.
Termite Problem, Modern Buildings and the, 177.
Tetrastrum heterocanthum, 464.
Thomas, Edward S., article by, 265.
Tiffany, L. H., article by, 271.
Tiffany and Ahlstrom, article by, 455.
Trautman, M. B., article by, 468.
Treubaria varia, 459.
Tuck, Ralph, article by, 278.

Uhrbrock, Richard Stephen, article by, 421.

Van Cleef, Eugene, article by, 277.
Variations in Muscular Efficiency, 285.
Varvel, Carl Dudley, article by, 17.
Ver Steeg, Karl, article by, 189, 277, 285, 368.
Vinal, William G., article by, 295.

Waller, A. E., article by, 29.
White, Geo. W., article by, 429.
Wiebe, A. H., article by, 120.
Wilde, Walter S., article by, 265.
Willard, C. J., articles by, 272, 274.
Williams, Stephen R., articles by, 115, 118, 264.
Witty, Paul A., article by, 421.
Wolford, J. J., article by, 274.
Wood, C. C., article by, 423.
Wright, A. J., article by, 283.
Wright, Frank J., article by, 278.